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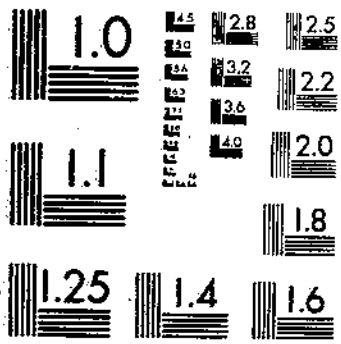

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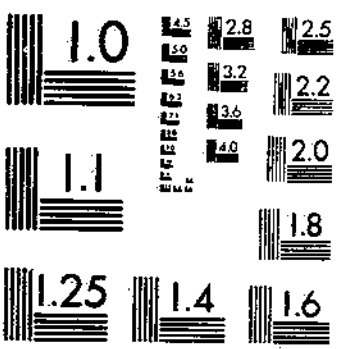

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

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WASHINGTON, D. C.

Classification of Flax Varieties, 1946[1]

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INTRODUCTION

The flax plant is indeed "most useful," as the translation of the species name *usitatissimum* indicates. Flax is grown for two purposes—its fiber and its seeds. The fiber, obtained from the stems, is woven into linen fabrics for use in the home and in the industries

[1] Submitted for publication May 22, 1952. The writer is indebted to R. C. Steadman for the color plates.

and for clothing. Other products are linen thread, twine, high-grade writing paper, and cigarette paper. The seed is the source of linseed oil, the most widely used drying oil, and linseed meal, a high-protein feed for livestock. Both the seed and the oil are used to some extent as human food.

Adequate descriptions of many of the commercial varieties of flax (*Linum usitatissimum* L.) grown in the United States are not available. Agronomists recognize the differences between the several geographical types and the important commercial varieties by certain characters of the seed, plant, and flowers. With the recent development of new varieties by breeding, however, there is need for a system of classification and description that will enable agronomists and growers to identify the varieties.

This bulletin contains keys to and descriptions of the principal groups and varieties of flax that were grown commercially in North America in 1946 and also of introduced varieties that may be of value to the flax breeder in the development of new varieties. The writer collected, through the generous cooperation of agronomists on every continent, more than 1,300 lots of flaxseed. Many of these represent similar varieties, or related strains, obtained through breeding and selection. Obviously, it would be confusing to describe this mass of material in detail. An attempt has been made to describe 62 varieties. These include a range of the important plant characters that can be used to distinguish varieties of flax.

ORIGIN OF CULTIVATED FLAX

The origin of flax is uncertain. Tammes in 1907 (*32*)[2] reviewed the literature of Heer (*17*), Wiesner (*38*), Candolle (*6*), and Neuweiler (*25*) on the possible origin of cultivated flax, especially the theories in regard to the species of flax found in the remains of the Swiss lake dwellings of the Stone Age. Tammes concluded (*33*) that there was no certainty as to the origin and dissemination of flax culture. Not one of the various theories is sufficiently supported by facts, and these theories all differ materially. It is extremely risky to base a theory upon the presence of certain relics apparently very hard to identify. Tammes believed that it is very probable that the origin of flax culture lies in southern Europe, the Near East, or in central Asia.

In later publications, Tammes (*34*, *35*) expressed the belief that *Linum angustifolium*, which is indigenous to the territory bordering the Mediterranean Sea, western Persia (Iran), and the Canary Islands, probably is the progenitor of cultivated flaxes. Tammes (*35*) pointed out that the two species have the same number of chromosomes, 30 diploid; that there is much diversity in the geographical races of *L. angustifolium;* that the two species are easily crossed and yield fertile hybrids; and that there is a general correspondence in the plant forms of the two species. Tammes (*35*, *p. 21*) concluded, "All this accompanied by the many points of correspondence in all kinds of characters leads to the supposition, that the wild *L. angustifolium* is the progenitor of cultivated flax."

[2] Italic numbers in parentheses refer to Literature Cited, p. 51.

Vavilov (*37, p. 187*) stated, "Of all the numerous species of the genus Linum wild flax, L. angustifolium . . . is the most akin to L. usitatissimum. Only this species gives rise to fertile hybrids when crossed with common flax. . . . This species is also represented by a great number of forms, readily crossed with cultivated varieties and undoubtedly genetically akin to common flax. . . . But there are no objective reasons to regard this comparatively narrow group of plants as the progenitor of all European and African flaxes. . . . According to our conceptions L. angustifolium represents a group of forms that close the series of variation of the species L. usitatissimum, a group which is akin, related but no more."

Vavilov seemed to think that flax culture may have originated independently in two or three regions. He said (*37, p. 183*), "According to all available data, the oldest regions of cultivated flax are in Asia: India, Bokhara, Afghanistan, Khoresm, Turkestan; on the coasts of the Mediterranean: Egypt, Algeria, Tunis, Spain, Italy, Greece, Asia Minor. In Central Europe the cultivation of flax also may be traced to prehistoric times." He considered the Indian flaxes, of short habit and with firm indehiscent bolls, as endemic for India.

The writer is inclined to agree with Tammes in the belief that *Linum angustifolium* is the species from which flaxes originated. It seems likely that wild flax was first gathered by primitive man as a source of food and perhaps cultivated long before the fine art of weaving had been developed in Egypt. It is not surprising, in view of the long period of flax cultivation, its use and selection for fiber and for seed, and its adaptation to natural crossing, that distinct types and varieties of flax have been developed and maintained in cultivation in Europe, Africa, and Asia.

FLAX IN ANCIENT EGYPT

Flax was a crop well developed in ancient Egyptian agriculture, and the art of weaving linen was known, as evidenced by the fact that ancient mummies were wrapped in linen cloth. Wilkinson (*39, pp. 427–428*), in his comprehensive work, shows several flax harvesting scenes from Egyptian tombs. Flax was always represented by a round boll or capsule and the plants were pulled, whereas wheat or barley was cut with a sickle (fig. 1, *B*). In figure 1, *A*, from a tomb at Eileithyia, workers are shown pulling flax, binding it in bundles, carrying the bundles to the stripper, and stripping off the bolls. In these scenes the standing flax is shown as nearly waist high. Wilkinson, however, was mistaken in calling this crop durra, a sorghum. Piedallu (*27*) gave conclusive proof that it was flax, not sorghum.

REVIEW OF LITERATURE

Linnaeus in 1753 (*23, p. 277*) named flax *Linum usitatissimum*, meaning most useful, or most used, flax. He probably had in mind the common blue-flowered fiber flax grown in Europe at that time. Miller in 1768 (*24*) added two names, *L. bienne* and *L. humile*, but it is doubtful if these should be considered other than varieties of *L. usitatissimum*. Hudson in 1778 (*19, p. 134*) described *L. angusti-*

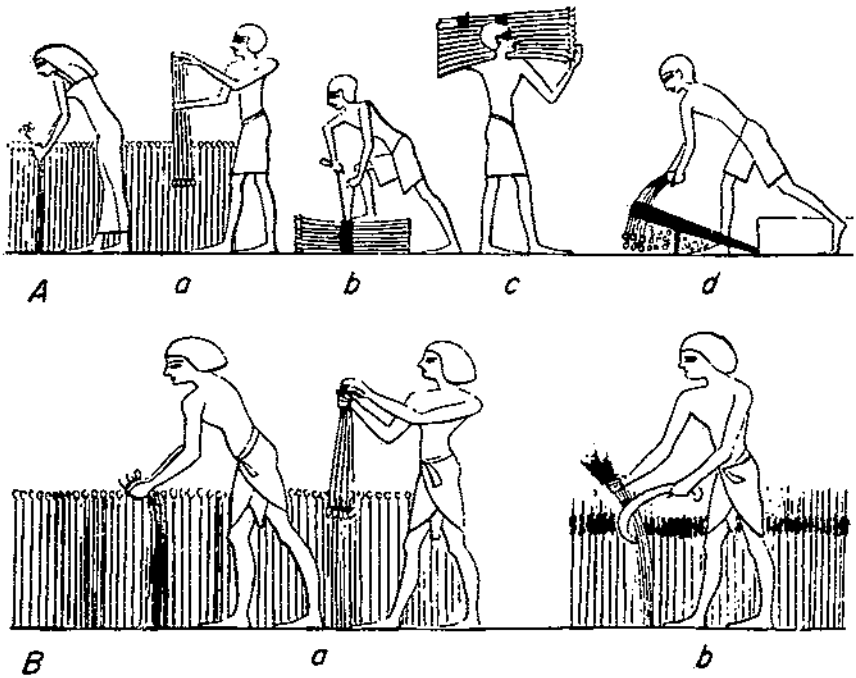


FIGURE 1.—Harvest scenes taken from an Egyptian tomb: *A*, *a*, Pulling flax, *b*, tying flax, *c*, carrying flax bundle, *d*, stripping seed from flax fiber; *B*, *a*, pulling fiber flax, *b*, cutting wheat.

folium, narrowleaf flax, which is native to the Mediterranean area, including Turkey, western Persia (Iran), and the Canary Islands. Boenninghausen in 1824 (*4*) and Dumortier in 1827 (*12*, *p. 111*) described *L. crepitans* (dehiscent flax), which is cultivated to a limited extent in a few localities in Europe.

Heer (*17*), Wiesner (*38*, *pp. 276–299*), Candolle (*6*, *pp. 119–130*), Tammes (*33*), Gentner (*16*), and Vavilov (*37*) discussed various theories in regard to the origin of flax and the relationship of certain species.

Howard and Khan in 1924 (*18*) described 26 varieties of Indian flaxes, using chiefly color differences of the flower parts to distinguish the 121 strains, or "types," described.

Vavilov in 1926 (*37*) reported in general terms the characteristics of certain groups of flaxes collected in different areas of the Union of Soviet Socialist Republics (U. S. S. R.), Turkestan, Africa, and India. No attempt was made to classify or describe varieties.

Kugler and Remussi in 1939 (*22*) reported certain flower, boll, and seed characters; wilt and rust resistance; and cold tolerance of a large collection of flax varieties obtained from many sources. The varieties were grouped according to source of seed, but otherwise they were not classified.

In the United States, Clark in 1920 (*7*) presented a group classification of some 50 varieties and strains of flax grown at the Northern Great Plains Field Station, Mandan, N. Dak., from 1914 to 1916. No detailed descriptions of the varieties were included. Dillman in

1936 (*9*) described 11 agronomic and botanical groups of flaxes and listed typical varieties in each group.

Flor in 1935 (*14*) reported the reaction of 165 flax varieties to 14 races of flax rust (*Melampsora lini* (Pers.) Lév.) collected in the north-central United States. In 1940 (*15*) he listed additional varieties of flax and new races of rust.

Ray in 1944 (*28*) reported the chromosome number of 30 species of *Linum*, including many varieties of *L. usitatissimum*, which, without exception, had $n=15$ and $2n=30$ chromosomes. This was true also of *L. angustifolium* and of *L. usitatissimum crepitans*.

Ascherson and Graebner (*3*) reviewed in considerable detail the European botanical literature on the genus *Linum*, including *L. usitatissimum* and related species or types. Flax literature is confusing because of the many synonyms used and the general tendency of earlier botanists to give species names to plants that now would be classed as varieties or, at most, distinct groups.

Schilling (*20, p. 57*) followed the suggestion of Ascherson and Graebner (*3*) in placing *angustifolium*, *crepitans*, and cultivated flaxes under *L. usitatissimum* in the broad sense as follows:

Linum usitatissimum (inclusive).
- Group I. *L. angustifolium* Huds.
- Group II. *L. usitatissimum* L.
  - A. *L. crepitans* Boenningh.—Dehiscent flax.
  - B. *L. vulgare* Boenningh.—Common flax.
    1. *L. biennе* Mill. and *L. hyemale romanum* Heer } Winter flax.
    2. *L. typicum*.—Summer flax.
       - a. *Macrospermum*.—Large-seeded flax.
       - b. *Microspermum*.—Small-seeded flax.

In most publications on American floras—Small (*31*), for example—the bolls of *L. usitatissimum* are described as indehiscent with smooth, or nonciliate, septa, in contrast to those of *L. humile* Mill., described as having dehiscent bolls with ciliate septa. The writer of this bulletin believes that *L. humile* is not a valid species but a variety of *L. usitatissimum* having larger flowers and bolls and shorter stems than the typical fiber flax (fig. 2). Miller (*24, Linum No. 2*) stated: "The second sort [*humile*] differs from the first [*usitatissimum*], in having stronger and shorter stalks branching out much more. The leaves are broader, the flowers are larger, and the petals are indented at their extremities. The seed-vessels are also much larger, and the foot stalks [pedicels] are longer; these differences are lasting, for I have cultivated this and the common Flax on the same ground upward of thirty years, and have never found either of them alter." If this flax had really been dehiscent, Miller certainly would have mentioned this striking character. Miller also described *L. biennе*, which most botanists consider similar to *L. hyemale romanum* Heer (Roman winter flax), a variety of *L. usitatissimum*.

Contrary to the conclusions of Small (*31*), the septa of the bolls of *L. usitatissimum* may be either ciliate or smooth, the ciliate condition being a simple dominant in crosses between varieties having ciliate and smooth septa. However, flaxes with dehiscent bolls, *L. usitatissimum crepitans* Boenningh., of which there are several varieties, all have smooth septa.

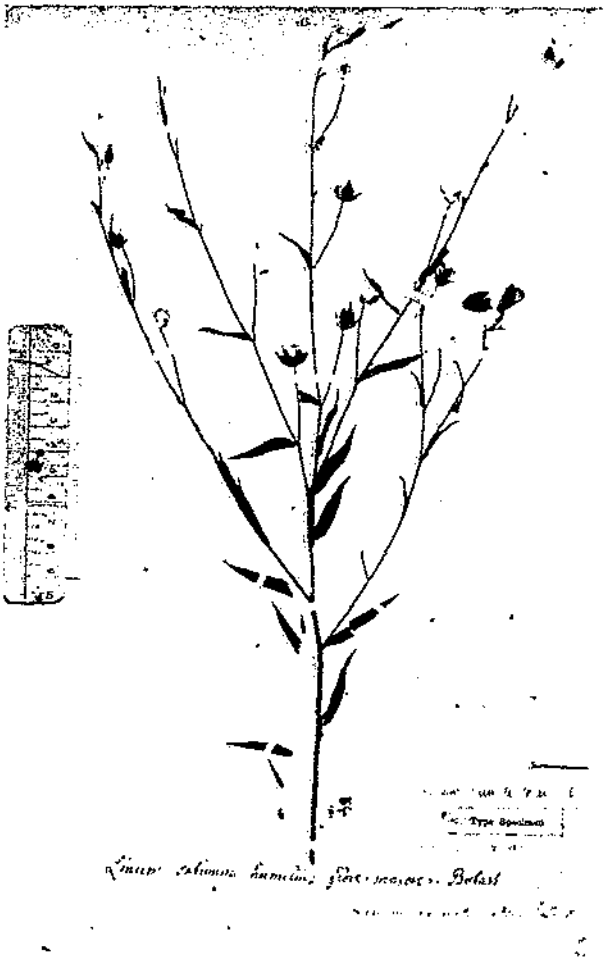


FIGURE 2.—Type specimen in the British Museum labeled in Miller's handwriting "*Linum sativum humilius flore majore*, Bobart." To this has been added by Solander, who dealt with the Miller Herbarium when it was acquired by Banks—"*Linum humile* Mill. Dict." Photograph courtesy of A. J. Wilmott, Assistant Keeper (European Herbarium), British Museum, October 1931.

PRESENT INVESTIGATION

The present investigation was begun in 1925 with the purpose of classifying by morphological and taxonomic characters 260 varieties and strains of flax represented at that time in the Cereal Investigation accession list (C. I. Nos.) of the Division of Cereal Crops and Diseases. The investigation included observations on certain diseases, especially wilt and rust, and the determination of the oil content and drying quality, or iodine number, of the oil. Since the inception of this study, hundreds of foreign introductions and new hybrid selections have been added to the collection and now (1950) the C. I. list exceeds 1,300 numbers.

COOPERATION

The writer has enjoyed the generous cooperation of agronomists of the State agricultural experiment stations and of foreign correspondents in furnishing seed of many varieties and types of flax. He is particularly indebted to A. C. Arny, formerly agronomist of the Minnesota Agricultural Experiment Station, and to Clyde McKee, director of the Montana Agricultural Experiment Station, for their long-continued cooperation in growing the flax nurseries; and to E. C. Stakman and J. J. Christensen, plant pathologists, University of Minnesota, and H. H. Flor, pathologist, Division of Cereal Crops and Diseases, working in cooperation with the North Dakota Agricultural Experiment Station, for data on the comparative wilt resistance and the rust reaction of varieties. The oil content, iodine number of the oil, and crude protein content of the meal of flax varieties were determined in the most part by T. H. Hopper, formerly agricultural chemist at the North Dakota Agricultural Experiment Station. H. L. Bolley, botanist, and T. E. Stoa, agronomist, at the North Dakota station, and J. C. Brinsmade, Jr., formerly in charge of flax breeding at the Northern Great Plains Field Station, Mandan, N. Dak., have aided in supplying seed and information on the origin of certain varieties.

SOURCES OF MATERIAL

Seed of many varieties were obtained from A. C. Arny, University Farm, St. Paul, Minn., and from H. L. Bolley and T. E. Stoa, of the North Dakota Agricultural Experiment Station. These included several older commercial varieties and many new varieties developed by breeding and selection. Foreign samples were obtained through the Division of Plant Exploration and Introduction of the United States Department of Agriculture. Through correspondence, the writer obtained some 20 varieties from Dr. Tine Tammes, University of Groningen, Netherlands; some 200 geographical types and varieties from the late N. I. Vavilov, Leningrad, U. S. S. R.; and many varieties from Egypt, Argentina, and Canada. The 123 "types" of Indian flax, described by Howard and Khan (*18*), were obtained by A. C. Arny and grown at University Farm, St. Paul, Minn., in 1925. The writer recorded certain notes and harvested the plants to obtain seed for further testing and observation.

The first study of varieties proved the necessity of working with pure lines. Few of either the foreign or the domestic varieties were pure, and it was necessary to select plants of the prevailing type to obtain pure lines for study. As little natural crossing occurs in flax, it was an easy matter to fix a high degree of uniformity by selection.

CLASSIFICATION NURSERIES

The earlier classification nurseries, grown at University Farm, St. Paul, Minn., included from 500 to 800 varieties, strains, and selections each year. Later the number was reduced to about 300. The varieties were grown in rows 17 feet long and 1 foot apart. The seed was sown so as to obtain a stand of 12 to 18 plants per foot of row. In certain nurseries the plants were spaced 1, 2, and 3 inches apart in the row in

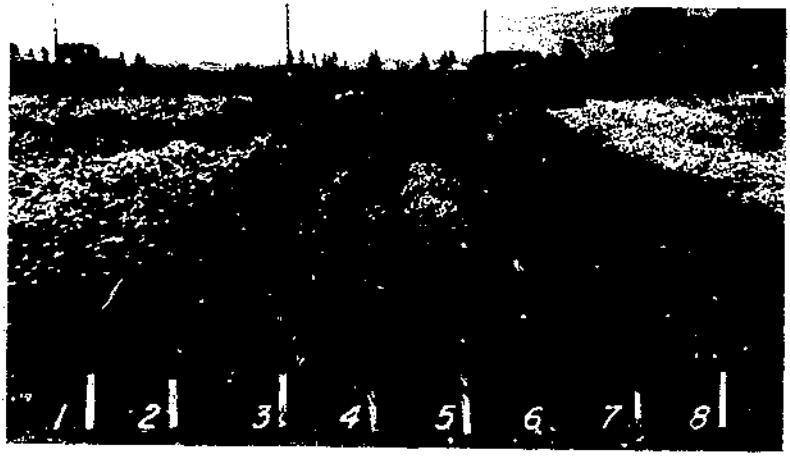


FIGURE 3.—Part of flax classification nursery at Bozeman, Mont., in 1939: (1) Beladi; (2) Indian, type 68; (3) Indian, type 121; (4) Indian, type 55; (5) Indian, type 46; (6) Indian, type 13; (7) Indian, type 12; (8) Ottawa white-flowered (border row). Photographed July 18, 1939.

order to observe the range in branching habit, height, and diameter of the stems.

Nurseries were grown in different agricultural areas to observe the effect of environment on the expression of varietal characters and thus to provide a description that would be usable wherever flax is likely to be grown. Nurseries were grown at University Farm, St. Paul, Minn., from 1925 to 1941; at Bozeman, Mont. (fig. 3), from 1926 to 1946; at Mandan, N. Dak., from 1925 to 1930; at San Antonio, Tex., from 1926 to 1931; and at El Centro, Calif., from 1936 to 1939. At San Antonio and El Centro the flax was fall-sown and grown as a winter crop; the growing season, from date of seeding to maturity, being about 5 months. At El Centro and at Bozeman, the flax in the nurseries was grown under irrigation. In the cool climate at Bozeman, elevation 5,000 feet, only one irrigation of about 4 inches of water, applied when the plants were in early bloom, was required. At El Centro, 50 feet below sea level, the long growing season and dry climate required five or six irrigations, or a total of about 2 acre-feet of water.

THE FLAX PLANT

The flax plant is an annual or, in mild climates, a winter annual 10 to 40 inches tall. The plant has a single taproot and usually a distinct main stem. The plant bears three types of branches: (1) Basal branches that occur as opposite pairs from the crown of the plant; (2) paniele branches that bear the seed bolls; and (3) adventitious branches that sometimes occur on the main stem (fig. 4). The cymose inflorescence, or so-called paniele, is formed by the continued forking of the upper part of the stem, each branch terminating in a flower bud or boll. The leaves are sessile, erect or ascending, nearly linear, with three veins, the midvein prominent. The color of the leaves is "elm green" or "light elm green",[3] fading to greenish yellow

[3] Quoted colors throughout bulletin are from Ridgway (29).

FIGURE 4. Flax plant, showing (A) three basal branches, (B) several adventitious branches on main stem, and (C) short panicle branches

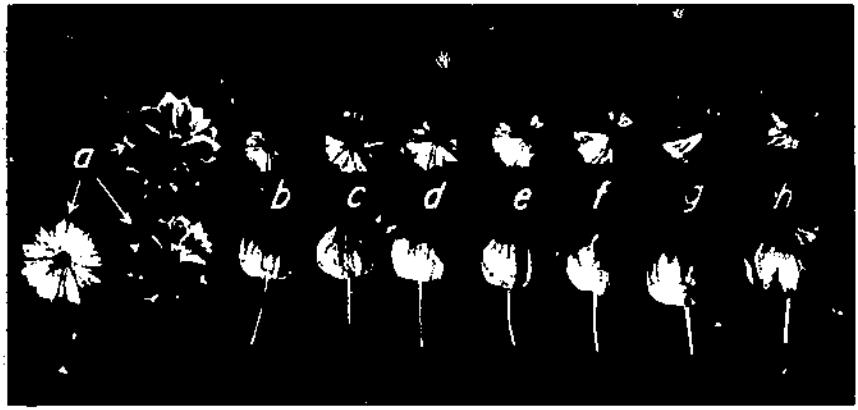


FIGURE 5. Three types of flax bolls: 1, Dehiscent; *B* to *D*, semidehiscent, subglobose; *E* to *H*, indehiscent, ovoid. *A*, *Crepitans*; *B*, Roman Winter; *C*, Redwing; *D*, Bison; *E*, Indian, type 46; *F*, Argentine; *G*, Linn Grande, *H*, C. I. 376.

and finally to brownish yellow on ripening. The characters of the mature plant that are most useful in classification are described in some detail.

Nearly all varieties of flax have a "spring habit" of growth—that is, the seedlings and young plants are erect in growth. Only two varieties described in this bulletin, Roman Winter and Turkey, have a "winter habit" of growth when fall-sown. In these varieties the plants are decumbent in early growth, the stems becoming erect in early March when the length of day approaches 12 hours.

In this classification certain characters of the mature plant are used, so far as possible, to distinguish taxonomic or geographical groups of related and similar varieties. These characters are the dehiscence and shape of the boll, or capsule, the ciliate or smooth character of septa of the boll, the color and size of the seed, and the height and branching habit of the plant. Characters of the flower, including the shape and size of the flowers and the color of the petals, anthers, and style, are useful for distinguishing between certain groups and varieties in the field. However, the attractive, distinct, natural color characters of the flowers are evanescent and are not easily preserved in the botanical specimens.

ANTHOCYANIN COLOR IN HYPOCOTYLS AND BOLLS

Anthocyanin purple pigment is always prominent in both the hypocotyl and the bolls of most Indian varieties. It often occurs in the hypocotyls of other varieties, except those of the narrow-petaled group.

THE BOLL OR CAPSULE

According to the nature of dehiscence, three distinct types (fig. 5) of flax boll can be recognized: (1) The dehiscent, which opens widely when ripe, scattering the seeds; (2) the indehiscent, ovoid, which remains closed when ripe; and (3) the semidehiscent, subglobose, in

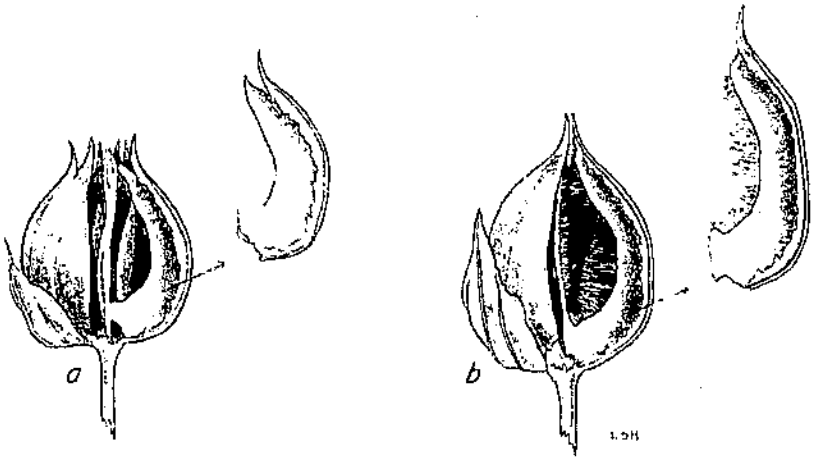


FIGURE 6.—Bolls and septa of bolls: *A*, Globose, semidehiscent boll and smooth septum; *B*, ovoid, indehiscent boll and ciliate septum. Drawn by Regina Olson Hughes.

which the five segments separate at the tip and crack along the margins. The type of dehiscence is perhaps the most notable character by which the important groups of flaxes can be distinguished. The dehiscent boll distinguishes the group *crepitans* of which there are several varieties. The indehiscent boll is typical of the Indian and Argentine varieties and also of certain varieties obtained from the Mediterranean area. The semidehiscent boll is characteristic of the fiber flaxes and of most seed-flax varieties grown in the United States and Canada. The character of dehiscence can be judged to the best advantage when the plants are thoroughly ripe and dry.

In certain varieties of hybrid origin there is some difficulty in recognizing the type of dehiscence, although at present there are few such varieties. In most cases the shape of the boll will determine the group to which the variety belongs, that is, the boll is either ovoid or subglobose. The ovoid bolls in which the segments separate very slightly at the tip are classed as indehiscent.

SEPTA OF THE BOLL

The flax boll (fig. 6) has five segments separated by complete septa. Each segment contains two ovules, or seeds, separated by a false septum of half-moon shape. The margin of this false septum either is smooth or it bears short, hairlike cilia. In most botanical works flax is described as having ciliate septa, but this is true only of certain varieties. The ciliate character is inherited as a simple dominant and is not known to be correlated with any other character of the plant. This character is of value in determining the purity of a variety and sometimes for distinguishing otherwise similar varieties. However, all varieties of the group *Crepitans*, dehiscent flaxes, have smooth septa.

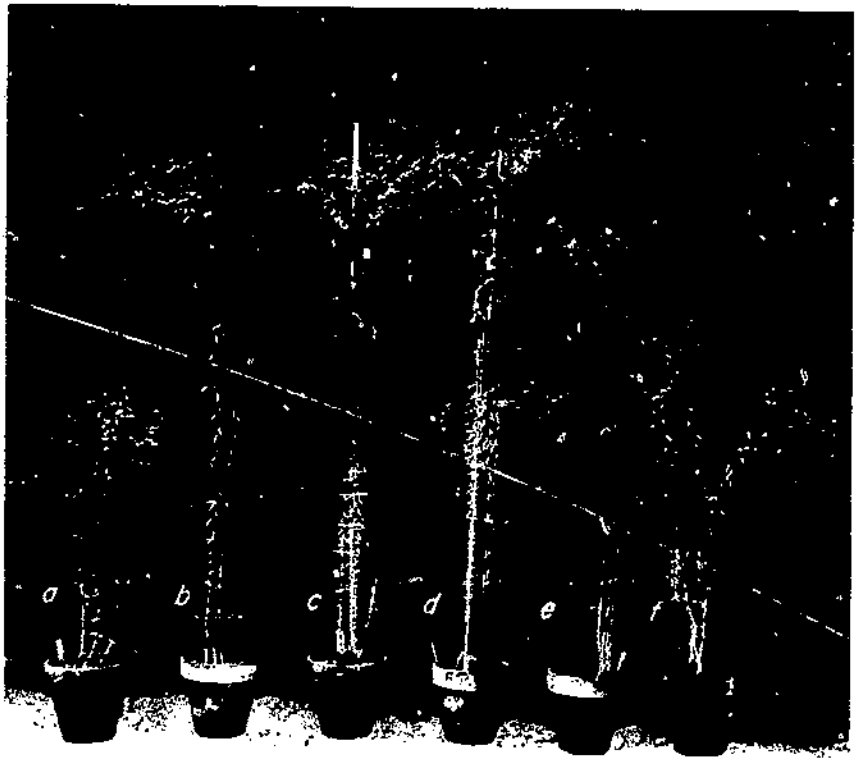


FIGURE 7.—Flax plants showing differences in height: *A*, Abidum, type 12; *B*, Ottawa 770B; *C*, Bison; *D*, Tammes crimped white; *E*, Roman Winter; and *F*, Album, type 13. (Plants grown in greenhouse during winter are taller than when grown as a summer crop in the field.)

HEIGHT OF PLANTS

The height (fig. 7) of the plant is important, because it may determine the method of harvesting, the strength of straw or resistance to lodging, the yield, and the value of the fiber. The height ranges from about 10 inches in some of the short Indian varieties to 40 inches or more in the taller fiber varieties. The height varies greatly with environmental conditions. Varieties grown as a fall-sown crop in the Imperial Valley of California usually are 4 to 8 inches taller than when grown as a spring-sown crop in Minnesota. The difference may be even greater with the Indian, Argentine, and Mediterranean groups, which are best adapted to a long growing season. Varieties are described as short, midheight, or tall. Bison, a variety of midheight, was used as a standard of comparison under different environmental conditions.

BRANCHING HABIT

The flax plant branches freely from the crown when grown in thin stands or in spaced plantings, but such basal branching is partly or entirely suppressed in thick stands. The effect of spacing on the branching habit of flax was reported by Dillman and Brinsmade (*11*), and typical plants from different spacings are shown in figure 8.

FIGURE 8. Effect of spacing upon the branching of Rio flax plants: *A*, Thick stand; *B* to *F*, spaced 1, 2, 3, 4, and 6 inches apart, respectively, in rows 12 inches apart.

The branching habit is most pronounced in varieties that have long been grown as a winter crop, that is, varieties adapted to a long growing season. This habit is perhaps the chief indication of what may be called a winter habit in flax. Plants of the Indian, Argentine, Mediterranean, and Abyssinian groups tend to branch more freely

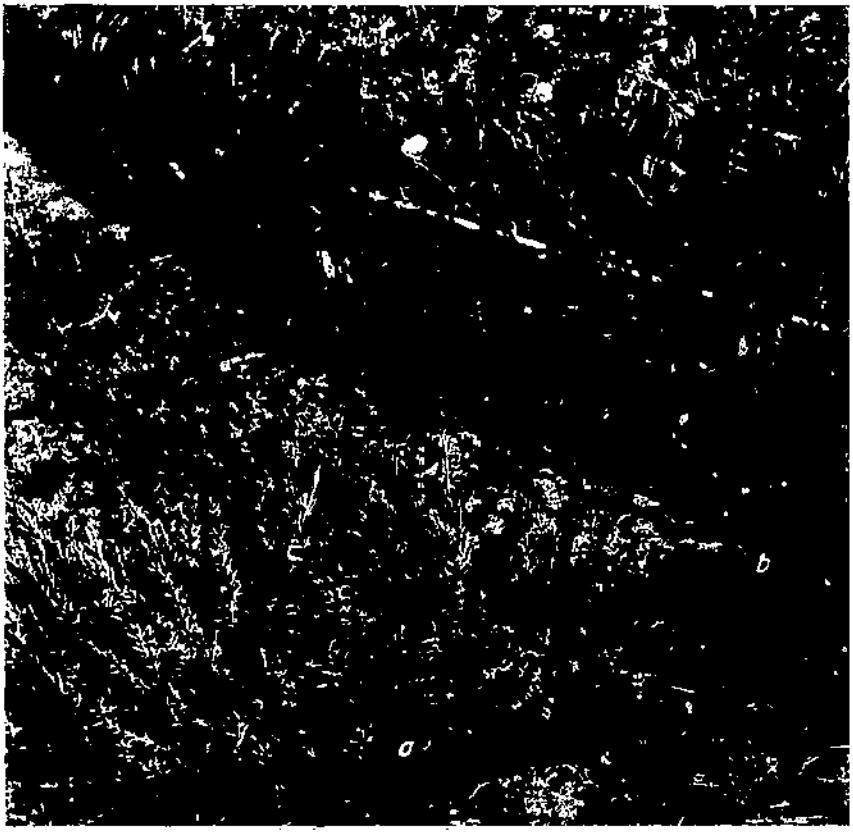


FIGURE 9.—Growth habit of flax; *A*, Turkey (C. I. 862), showing decumbent, winter habit when fall-sown; *B*, Arrow, showing erect, spring habit (characteristic of all varieties except Turkey and Roman Winter). (Photographed March 1, 1952, at Kenedy, Tex.)

and to grow in height more slowly than do those of the typical fiber and seed-flax varieties (fig. 9).

DIAMETER OF STEMS

The diameter of the stem, like height and branching, varies greatly with differences in plant spacing and other environmental conditions. In this study, stem diameter was measured about 4 inches above the ground on plants grown approximately 1 inch apart in rows 1 foot apart. Three classes are used in describing varieties: Stems small (1.0 to 1.7 mm.), midsize (1.5 to 2.5 mm.), and large (2.3 to 4.0 mm.). The flax stem becomes a hollow cylinder as it matures, owing to the breaking down of the central pith cells. The woody cylinder surrounded by the fiber bundles gives the flax stem its strength and resistance to lodging. Stiffness of stems is, to some degree, a varietal character, although differences in the extent of lodging in the field often depend on the stage of growth at which the plants are subjected to rain and wind. Flax in the green-boll stage is most susceptible to lodging.

FIGURE 10.—Typical flax plants of (*A*) Beladi (C. I. 377), showing open, sparsely bolled panicle; and (*B*) Abyssinian (C. I. 302), showing short, much-branched and leafy type of plant.

LEAVES

Flax leaves are sessile, linear, erect, or spreading; three-veined, the midvein prominent. The color is "elm green" or "light elm green" (*29*). The leaves are arranged spirally around the stem except at the base of the stem where they are opposite.

The size and number of leaves on a unit length of stem varies in different groups and varieties. In the short, leafy Abyssinian flaxes (fig. 10, *B*), the leaves are small, 4 to 5 mm. wide, and are close together (5 mm. apart) on the stem. In the Argentine, Mediterranean (fig. 10, *A*), and dehiscent varieties the leaves are large, 6 to 8 mm. wide, and are more widely spaced, 7 to 10 mm. apart, on the stem.

COLOR OF SEEDS

The seeds of flax are brown, "cinnamon brown," yellow, chamois yellow, greenish yellow, mottled ("Isabella"), or mummy brown. The color of seeds is of value in distinguishing varieties within each group.

SIZE OF SEEDS

The seed size is an important character in distinguishing varieties (fig. 11). The length ranges from approximately 2.5 mm. in *Linum angustifolium* to 6 mm. or more in the large-seeded Mediterranean varieties. The weight of 1,000 seeds in grams is perhaps the better measure of seed size. In this bulletin the weight is expressed in milligrams per seed. Four groups are recognized: (1) Seeds small, 3.5 to 5.0 mg.; (2) midsize, 4.5 to 7.0 mg.; (3) large, 6.5 to 9.0 mg.; and (4) very large, 8.5 to 11.0 mg. The seed weight varies under different growth conditions. In the Bison flax, for example, a range from 4.5 to 7.0 mg. has been recorded in dry-land and irrigated crops, respectively.

SHAPE OF SEEDS

In some small-seeded varieties—Buda, for example—the seeds are more or less beaked, or rostellate (fig. 12). This character is less prominent in large-seeded varieties and is absent or not prominent in the group *crepitans*.

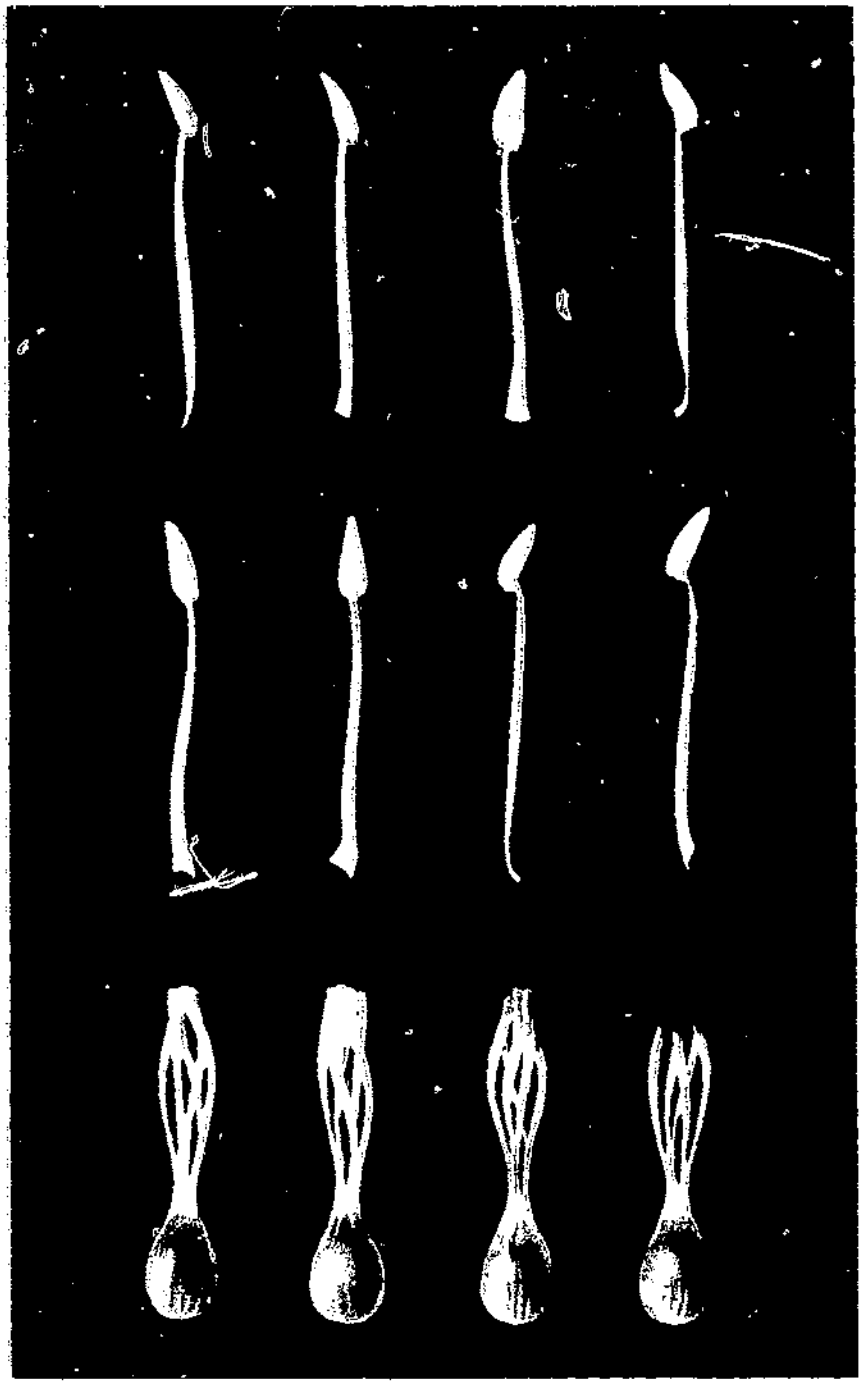
THE FLAX FLOWER

The size and shape of the flax flower is determined by the size, shape, and spread of the petals. Four fairly distinct types of flower (fig. 13) can be recognized: (1) The common funnelform flower in which the petals are overlapping or partly separate; (2) the tubular flower, in which the petals remain rolled in the form of a tube, found only in a few strains of Indian flax; (3) the star-shaped, or "crimped white" flower, in which the narrow petals are inrolled at the margins and widely separate; and (4) the diskform flower, in which the large flat petals spread widely in the form of a disk or saucer. In the description of varieties, the shape of flower, the average spread of the open flower, and the width and length of the petals are recorded. These measurements vary somewhat according to conditions of growth. Details of the flax flower are shown in figure 14.

PETAL COLOR

The petals of the flax flower are either white or some hue of blue, violet, purple, or pink (pl. 1). Tammes (*35*) has noted eight genetic factors that determine or modify the color of the petal, and according to Shaw and associates (*30*) there are perhaps additional factors involved in the Indian flaxes. In genetic investigations it is important to distinguish the varieties with pure white petals from varieties having pale tints of blue or pink, which superficially appear to be white. A trace of color can be determined by examination of the flower buds, or by placing the petals in dilute hydrochloric acid—the anthocyanin test—in which the petals that have a trace of color will turn slightly red, whereas the pure white petals remain white.

Flax flowers. Upper row: Tubular flower of C. I. 156 (left); small lavender petals of Crepitans (right). Center row: Rio of the Argentine type (left); Crete of the Mediterranean type (right). Lower row: Lilac color of Tammes (left); pale pink petals and yellow anthers of the Golden variety (right).



Upper row: Stamens showing yellow anthers and white filaments. Center row: Stamens showing blue anthers with filaments white to three-fourths blue. Lower row: Pistils showing white to deep purple stigmas and white to light blue styles.

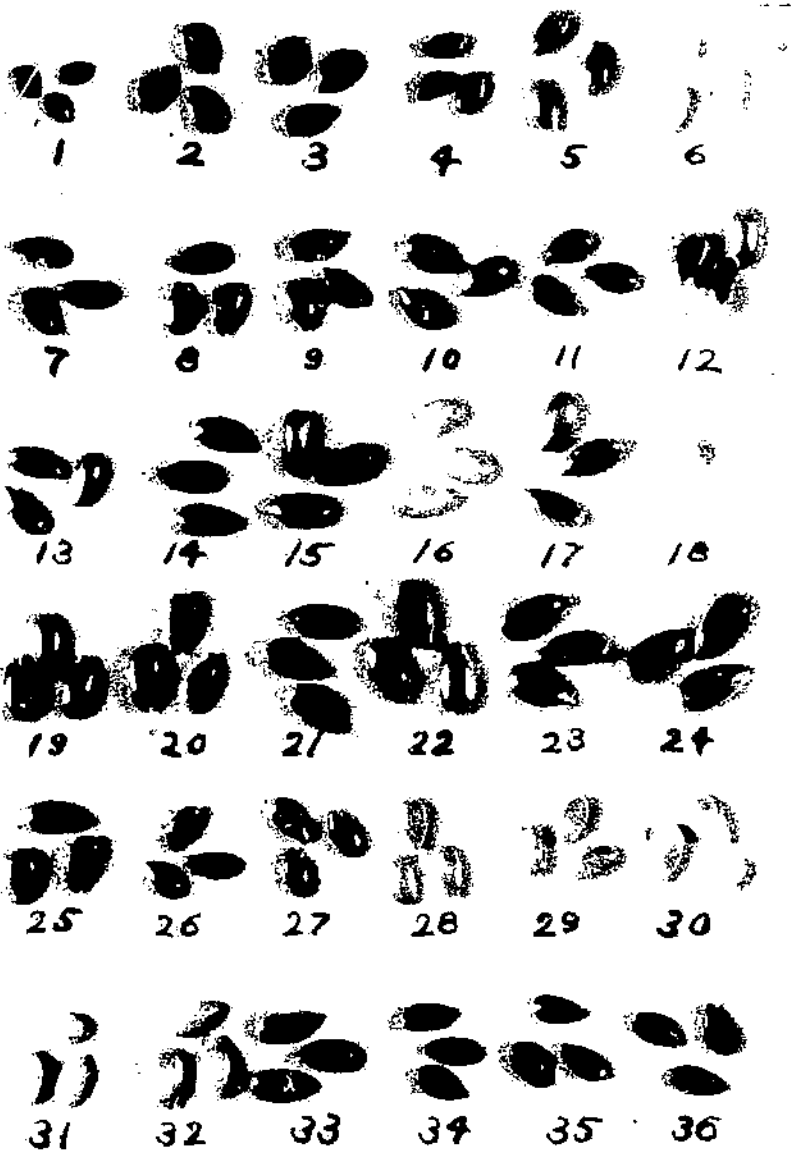


FIGURE 11.—Seeds of flax varieties and types: *1*, *Linum angustifolium*; *2*, *L. angustifolium crepitans* var. Coimbricum; *3*, *L. angustifolium crepitans* var. Germanicum; *4*, Roman Winter; *5*, Abyssinian Brown; *6*, Abyssinian Yellow-seed; *7*, Linota; *8*, J. W. S.; *9*, Redwing; *10*, Bison; *11*, Newland; *12*, Novelty; *13*, Indian, type 12; *14*, Indian, type 68; *15*, Indian, type 53; *16*, Indian, type 9; *17*, Indian, type 13; *18*, Indian, type 1; *19*, Argentine (C. I. 390); *20*, Malabrigo; *21*, Argentine (C. I. 342); *22*, Lino Grande; *23*, Morocco; *24*, Cyprus; *25*, Diadem; *26*, N. D. R. 714; *27*, Common White; *28* and *29*, Tammes crimped-white; *30*, Ottawa 770B; *31*, Bolley Golden; *32*, Williston Golden; *33*, Long 66; *34*, Tall Pink; *35*, Deep Pink; *36*, Common Pink.

FIGURE 12.—Seeds of six varieties of flax: *A*, Bison; *B*, Redwing; *C*, Linota; *D*, Argentine; *E*, Buda; *F*, Bolley Golden (yellow-seeded).

Petal color refers to the basic color of the petal; that is, the color of the "intervenia," or the space between the veins. The veins, which spread fanlike from the base of the petal, usually are of a darker or deeper tone of the same basic color as the intervenia. In certain varieties in which the veins are of the same tone as the intervenia, the petals appear to be without veins. In other varieties the veins are of a different hue from the intervenia; for example, pale-pink petals usually have violet veins. Petal color varies somewhat according to the growing conditions of the plant, and especially on exposure after opening of the bud. Under dry conditions petal colors appear paler than where soil moisture is plentiful. Violet hues especially fade rapidly on exposure to sunlight. Therefore, in noting the color

FIGURE 13.—Flax flowers of the four principal types: (1) The common funnel-form flower; (2) tubular; (3) star-shaped, or "crimped-white"; and (4) the large saucer- or disk-shaped flower.

of petals it is best to choose freshly opened flowers on plants grown under favorable moisture conditions.

Petal color was compared with the plates in Ridgway's Color Standards and Color Nomenclature, whenever possible, but the paler tints are not easy to match and are described as pale blue or very pale blue. The typical common flax blue matches approximately "light wistaria violet" (*29, pl. 23, 59′ d*); the deep flax blue of the Bison variety matches "wistaria blue" (*29, pl. 23, 57′ b*); whereas, the violet hues of certain Indian varieties can be matched with shades of violet (*29, pl. 25*). The color designated "flax-flower blue" by Ridgway (*29, pl. 21*) does not occur in any variety grown by the writer.

The obvious color differences in petals of distinct varieties are not easy to describe in writing. Color terms, such as blue, violet, mauve, lilac, and lavender, do not always mean the same thing to different people. The color terms used in this bulletin, the type variety, and the approximate matching color in Ridgway (*29*) are given in table 1.

TABLE 1.—*Type variety and the approximate matching color in Ridgway's Color Standards and Color Nomenclature of color terms used for petals*

Color term	Type variety	Approximate Ridgway[1] color
Deep flax blue	Bison	Wistaria blue (pl. 23, 57′ *b*).
Flax blue	Linota	Light wistaria violet (pl. 23, 59′ *d*).
Light blue	Redwing	Pale wistaria violet (pl. 23, 59′ *f*).
Pale blue	C. I. 446	
Dull light blue	Rigo (C. I. 690)	Pale verbena violet (pl. 36, 55″ *f*).
Lavender	*Crepitans*	Lavender (pl. 36, 59″ *f*).
Bluish violet	Minerva	Wistaria violet (pl. 23, 59′ *b*).
Violet	Indian, type 121[2]	Lavender-violet (pl. 25, 61′ *b*).
Light violet	Beladi	Light lavender-violet (pl. 25, 61′ *d*).
Light mauve	Light mauve	Light mauve (pl. 25, 63′ *d*).
Pink	C. I. 173 3	
Light pink	C. I. 354	
Pale pink	Bolley Golden	
Common white	Pinnacle	
"Crimped-white"	Tammes crimped-white	

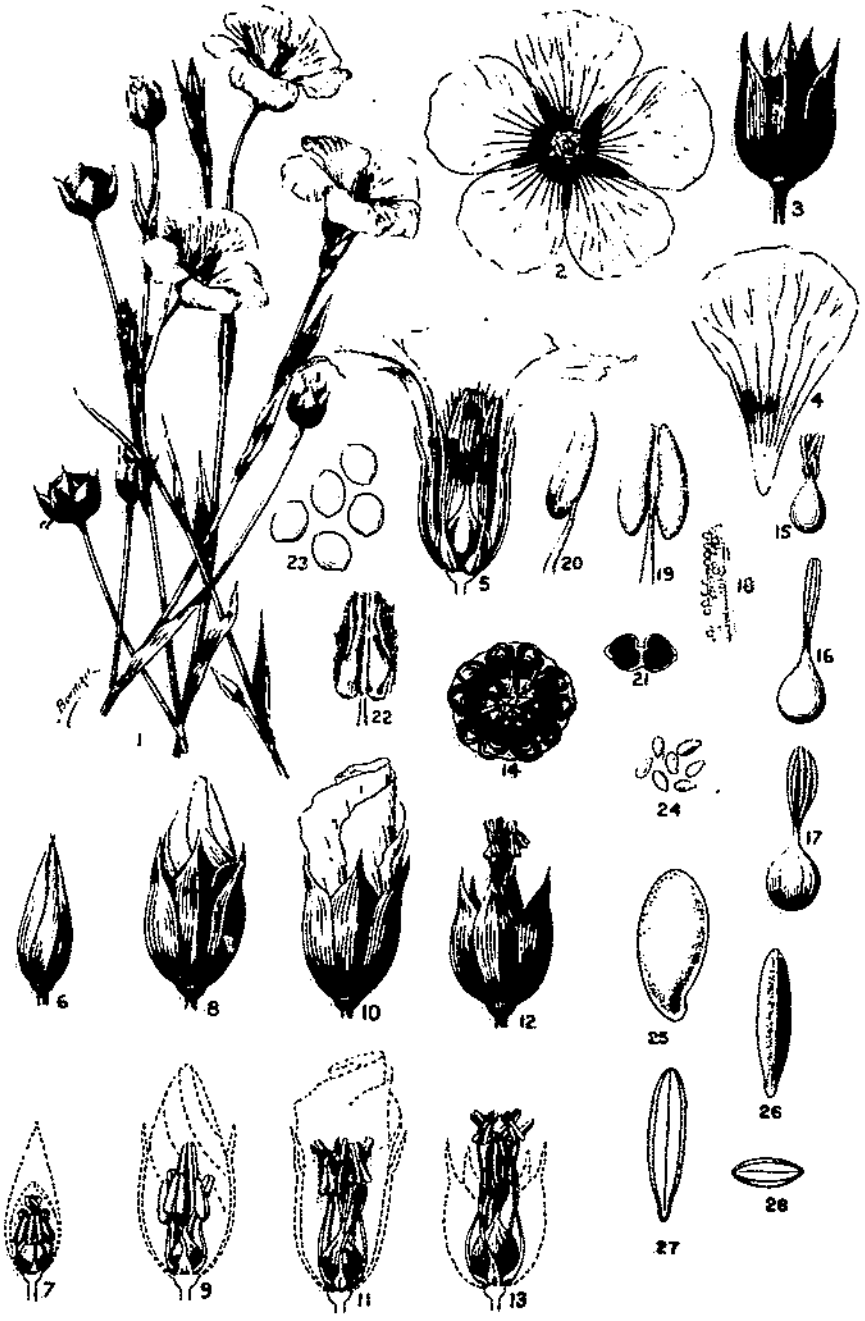
[1] Ridgway colors appear in quotes in varietal descriptions.
[2] Howard and Khan (*18*).

ANTHER COLOR

For the purpose of classification the anthers may be described as blue or yellow. In most blue-flowered and white-flowered varieties the anther walls are blue and the pollen pale blue. In varieties with yellow anthers, the anther walls are cream yellow or very pale yellow and the pollen is pale yellow, lemon yellow, or orange yellow. In the description of varieties, only the over-all color of the anthers, whether blue or yellow, are noted.

FILAMENT COLOR

The filaments of the stamens are either white or more or less colored. The color always extends from the anther downward, and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it may be a mere trace or it may extend to two-thirds the length of the filament. The color usually is some tone of blue or violet blue (pl. 2).

COLOR OF THE STYLE

The style, also, is either white or colored. Color on the style extends from the base upward; the color may be a mere trace next to the ovary, or it may extend to the stigma (pl. 2). The approximate extent of the coloring, as "a trace of blue" or "one-half blue," is recorded in the description of varieties. The color of the style often appears bright blue in contrast to the violet or pink hue of the petals.

The stigma may be white, lavender, violet, pink, or purple in different varieties, the color being most striking at the tip of the stigma (the stigmatic surface) in flowers that have been open for some time. A colored stigma occurs only when the style is colored; that is, a pure white style has a white stigma. The color of the stigma, however, is rarely distinctive enough to be of value in distinguishing varieties.

CLASSIFICATION KEYS

The numerous varieties and strains of flax grown in this study have been arranged in geographical or natural groups, based on certain morphological characters. Such natural groups are readily recognized by agronomists who are familiar with the flax crop. It seems best, therefore, to describe these groups and then key out the important varieties under each group. In the present classification, the groups are arranged in what appears to be a natural order, beginning with the more primitive or those long in cultivation and extending to those selected for special purposes such as fiber flaxes and disease-resistant seed flaxes.

Thirty years ago (1920) such geographical groups as Abyssinian, Indian, Argentine, and Mediterranean were distinct and readily recognized commercial types. Now (1946), with the recent interest in flax breeding, there has been a world-wide distribution of flax varieties, and these original indigenous types are grown by agronomists and flax breeders in many countries. It is the purpose of the writer to describe these types or groups so that they can be recognized by plant breeders, farmers, and others interested in the flax crop.

FIGURE 14.—Flax flower and seed. (1) Upper stems showing leaves, flowers, and boll (a) about natural size; (2) expanded flower; (3) calyx after anthesis and the shedding of petals; (4) upper surface of a petal; (5) section of a flower showing calyx, corolla, the 5 stamens and the 5 stigmas; (6 to 13) 4 stages of flower opening and anthesis, (6 and 7) 2 days before anthesis, (8 and 9) late afternoon of day before anthesis, (10 and 11) anthesis occurring at sunrise, (12 and 13) 3 to 6 hours after anthesis; (14) cross section of boll, showing the 10 ovules (seeds) developed in the 5 carpels; (15, 16, and 17) pistil before and during anthesis; (18) part of stigma, greatly magnified, showing adhering pollen grains; (19) dorso-ventral view of anther with a part of the filament; (20) lateral view of anther; (21) cross section of anther; (22) dehiscing anther; (23) pollen grains, greatly magnified; (24) seeds, natural size; (25 and 26) seed magnified; (27) seed dorso-ventral longitudinal (sagittal) section, showing cotyledons and surrounding endosperm; (28) cross section of seed, showing cotyledons and surrounding endosperm.

KEY TO CULTIVATED FLAX AND RELATED SPECIES OF *LINUM*

Page

Bolls dehiscent, small, cup-shaped.
  Plants annual or winter annual, short to midheight, stems slender, branched.
    Seeds brown.
      Seeds very small (1.5 to 2.5 mg.).
        Septa ciliate.
          Linum angustifolium Huds. 26

Bolls widely dehiscent, large, saucer-shaped.
  Plants short to midheight, stems stout, erect, sparsely branched.
    Seeds brown.
      Seeds small to midsize (3.5 to 6.5 mg.), not beaked.
        Septa smooth.
          Linum usitatissimum crepitans Boenningh. (I) 27

Bolls indehiscent, ovoid; or semidehiscent, globose to subglobose.
  Plants short to tall (10 to 40 in.), branching from the crown, stems small to large, erect (except few varieties of winter habit).
    Seeds brown, yellow, chamois, or ecru olive.
      Seeds small to very large (3.5 to 11.0 mg.).
        Septa ciliate or smooth.
          Flowers funnelform to diskform, small to large.
            Petals white, blue, violet, or pink; anthers blue or yellow.
              Common flax (seed flax and fiber flax) *Linum usitatissimum* L. 28

KEY TO GROUPS OF COMMON FLAX

Bolls indehiscent, ovoid, midsize.
  Plants short to midheight, usually with two or more basal branches, stems stout.
    Seeds brown.
      Seeds midsize to large (4.5 to 8.0 mg.).
        Septa ciliate or smooth.
          Flowers funnelform or tubular, small to midsize.
            Petals pale blue to violet; anthers blue or yellow.
              Indian varieties (II) 28

Bolls indehiscent, ovoid, large.
  Plants short to midheight, stems stout, spreading; panicle midlong, open.
    Seeds brown.
      Seeds large to very large (6.5 to 11.0 mg.).
        Septa ciliate.
          Flowers funnelform or broadly funnelform, large.
            Petals flax blue; anthers blue.
              Mediterranean varieties (III) 29

Bolls indehiscent, ovoid, or partly semidehiscent, globose, midsize or large.
  Plants midheight, branched, stems midsize to large, erect.
    Seeds brown.
      Seeds midsize to large (4.5 to 9.0 mg.).
        Septa ciliate.
          Flowers broadly funnelform to diskform, midlarge to large.
            Petals broad, light blue to violet blue; anthers blue.
              Argentine varieties (IV) 31

Bolls indehiscent, ovoid, or semidehiscent, globose, midlarge or large.
  Plants short to midheight; stems midsize, spreading.
    Seeds yellow, chamois, or mottled.
      Seeds midsize to large (4.5 to 11.0 mg.).
        Septa ciliate or smooth.
          Flowers funnelform, midsize to large.
            Petals pale pink, veins violet; anthers light or salmon yellow.
              Golden varieties (V) 34

Page

Bolls semidehiscent, subglobose to globose, small or midsize.
Plants winter habit, decumbent in early growth, much-branched, mid-height at maturity.
Seeds brown.
Seeds small (3.5 to 6.0 mg.).
Septa ciliate.
Flowers funnelform, midsize.
Petals flax blue; anthers blue.
Winter varieties (VI) . . . 37

Plants short to midheight, stems small, much-branched, leaves small, numerous, and closely spaced.
Seeds brown or yellow.
Seeds small (4.0 to 5.0 mg.), beak prominent.
Septa smooth.
Flowers small to midsize.
Petals flax blue; anthers blue.
Abyssinian varieties (VII) . . . 38

Plants midheight, usually few or no basal branches, stems small to midsize.
Seeds brown or yellow.
Seeds small to large (3.5 to 9.0 mg.).
Septa ciliate or smooth.
Flowers funnelform, small to large.
Petals pale blue to deep flax blue, or white; anthers blue or yellow.
North American seed-flax varieties (VIII) . . . 39

Plants tall.
Seeds brown.
Seeds small (3.5 to 5.0 mg.).
Septa ciliate or smooth.
Flowers funnelform, midsize.
Petals flax blue or white; anthers blue.
Fiber flax varieties (IX) . . . 46

Plants short, midheight, or tall.
Seeds brown, yellow, pale yellow, or greenish-yellow ("eeru-olive").
Seeds small to large (3.5 to 9.0 mg.).
Septa ciliate or smooth.
Petals white, narrow, involute; anthers yellow.
Narrow-petaled varieties (angustipetalum) (X) . . . 49

KEY TO DEHISCENT VARIETIES (I)

Bolls widely dehiscent, globose before dehiscing.
Septa smooth.
Seeds brown, not beaked.
Plant midheight; seeds small . . . UCRANICUM . . 27
Plant short to midheight.
Plant early; seeds small . . . GERMANICUM . . 27
Plant very early; seeds midsize . . . COMMUNE . . 27

KEY TO INDIAN VARIETIES (II)

Bolls indehiscent, ovoid, midsize.
Plant short to midheight, stems stout.
Seeds brown, midsize to large.
Septa ciliate.
Flowers tubular.
Petals bluish violet; anthers blue . . . JALACUM . . 28
Flowers funnelform.
Petals flax blue; anthers blue . . . PUNJAB . . 28
Septa smooth.
Petals very pale blue; anthers cream yellow . . . ALBIDUM, TYPE 12 . . 29
Petals bluish violet; anthers blue . . . COMMUNE, TYPE 55 . . 29
Petals violet; anthers blue . . . SATIVUM, TYPE 121 . . 29

KEY TO MEDITERRANEAN VARIETIES (III)

Page

Bolls indehiscent, ovoid, large.
Septa ciliate.
Seeds brown, large to very large.
Plant short to midheight.
Flowers broadly funnelform, large.
Petals flax blue; anthers blue.
Filaments trace of blue ..... CYPRUS .. 30
Filaments white.
Style trace of blue ..... MOROCCO .. 30
Style white ..... LINO GRANDE .. 30
Flowers funnelform, large.
Petals flax blue; anthers blue.
Filaments two-third violet blue ..... BELADI .. 31
Filaments trace of light blue ..... GIZA .. 31

KEY TO ARGENTINE VARIETIES (IV)

Bolls indehiscent, ovoid, midsize.
Septa ciliate.
Plant midheight (usually taller when fall-sown).
Seeds brown, midsize to large.
Flowers broadly funnelform to diskform, large.
Petals flax blue, broad, overlapping; anthers blue; filaments white.
Style white ..... RIO .. 32
Style one-fourth blue ..... MALABRIGO .. 32
Petals light blue, partly separate; anthers blue ..... KLEIN II .. 32
Petals "pale verbena violet"; anthers blue ..... RIGO .. 33
Petals "light mauve"; anthers blue ..... LIGHT MAUVE .. 33
Bolls semidehiscent, globose, large.
Septa ciliate.
Plant midheight; stems stout.
Seeds brown, midsize to large.
Flowers broadly funnelform, large ..... ARGENTINE HYBRIDS .. 33
Petals light blue; anthers blue.
Seeds midsize ..... B-5128 .. 33
Petals flax blue; anthers blue.
Seeds large ..... WALSH .. 33

KEY TO GOLDEN VARIETIES (V)

Bolls indehiscent, ovoid, or slightly semidehiscent, globose, midsize or large.
Plant short to midheight.
Flowers funnelform, midsize to large.
Petals pale pink; anthers light or salmon yellow.
Septa ciliate.
Seeds yellow.
Seeds very large (9.4 to 10.6 mg.) ..... HOSHANGABAD .. 34
Seeds midsize (5.5 to 7.0 mg.).
Style white ..... BOLLEY GOLDEN .. 34
Style trace to one-third blue ..... REBC .. 36
Septa smooth.
Seeds chamois, midsize (4.5 to 7.0 mg.) LETHBRIDGE GOLDEN .. 36
Seeds mottled, or "Isabella" color, midsize (5.5 to 7.0 mg.) .. SMOKY GOLDEN .. 36

KEY TO WINTER VARIETIES (VI)

Bolls semidehiscent, subglobose to globose, small or midsize.
Septa ciliate.
Plant winter habit, decumbent in early growth, midheight and erect at maturity.
Seeds brown.
Seeds small (3.5 to 4.0 mg.); stems small to midsize ..... ROMAN WINTER .. 37
Seeds midsize (4.0 to 6.0 mg.); stems midsize, stout ... TURKEY .. 37

KEY TO ABYSSINIAN VARIETIES (VII)

Page

Bolls semidehiscent, subglobose to globose.
Septa smooth.
Plant short to midheight, much-branched, and leafy.
Seeds small, beak prominent.
Seeds yellow ..... ABYSSINIAN YELLOW-SEED .. 38
Seeds brown ..... ABYSSINIAN BROWN .. 38

KEY TO NORTH AMERICAN SEED-FLAX (LINSEED) VARIETIES (VIII)

Bolls semidehiscent, subglobose to globose.
Septa smooth.
Plant midheight, stems midsize.
Seeds brown.
Flowers funnelform, midsize.
Petals flax blue; anthers blue.
Plant susceptible to wilt.
Seeds small (4.5 to 5.5 mg.) ..... FRONTIER .. 39
NEWLAND .. 39
Plant moderately resistant to wilt.
Seeds midsize (4.5 to 6.0 mg.), dull brown ..... RENEW .. 39
Seeds midsize (5.0 to 6.5 mg.), bright brown ... DAKOTA .. 40
Petals white; anthers blue.
Plant slender, early to midseason.
Seeds small to midsize (3.5 to 4.8 mg.) .....
OTTAWA WHITE-FLOWERED .. 40
Plant stout, midseason to late.
Seeds large (6.0 to 8.0 mg.) ..... VICTORY .. 40
Flowers funnelform, large.
Petals white; anthers blue.
Plant stout, midseason.
Seeds midsize (5.5 to 7.0 mg.) ..... DIADEM .. 41
Flowers funnelform, small.
Petals white; anthers yellow.
Seeds small (4.2 to 5.0 mg.) ..... JANE .. 41
Septa ciliate.
Plant midheight, stems small to midsize.
Seeds brown.
Seeds small (3.5 to 5.0 mg.).
Flowers funnelform, midsize.
Petals flax blue; anthers blue.
Plant susceptible or slightly resistant to wilt ... PRIMOST .. 41
Plant moderately resistant or resistant to wilt.
Stems slender, sparsely branched ..... N.D.R. 313 .. 43
LINOTA .. 43
Stems stout, branched, leafy ..... BUDA .. 43
Seeds midsize (4.5 to 7.0 mg.).
Flowers funnelform, midsize.
Petals light blue; anthers blue.
Plant early ..... REDWING .. 43
Plant midseason (taller than Redwing) ..... BIWING .. 44
Petals flax blue; anthers blue.
Plant early ..... SHEYENNE .. 44
Plant midseason (taller than Sheyenne) ..... ARROW .. 44
Petals deep flax blue; anthers blue.
Plant early ..... REDSON .. 45
Plant midseason (taller than Redson).
Seeds midsize (5.5 to 7.0 mg.) ..... BISON .. 45
Seeds midsize (4.8 to 6.2 mg.) ..... KOTO .. 45
Seeds "cinnamon-brown" with tawny tip.
Seeds midsize (4.5 to 7.0 mg.).
Flowers funnelform, midsize.
Petals flax blue; anthers blue ..... NOVELTY .. 46
Petals light blue; anthers blue ..... ROYAL .. 46

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Page

Bolls semidehiscent, subglobose to globose—Continued
Septa ciliate—Continued
Plant midheight etc.—Continued
Seeds yellow.
Seeds midsize (5.5 to 6.0 mg.).
Flowers funnelform, midsize.
Petals bluish violet.....MINERVA.. 46

KEY TO FIBER FLAX VARIETIES (IX)

Bolls semidehiscent, subglobose.
Plant tall, stems midsize.
Seeds brown, small (3.5 to 5.0 mg.).
Petals flax blue; anthers blue.
Septa ciliate.....SAGINAW.. 47
Septa smooth.....J. W. S.. 47
CIRRUS.. 48
Petals white; anthers blue.
Septa ciliate.....PINNACLE.. 48
Septa smooth.....CONCURRENT.. 48

KEY TO NARROW-PETALED VARIETIES (*ANGUSTIPETALUM*) (X)

Bolls semidehiscent, subglobose or globose.
Flowers star-shaped.
Petals white, narrow, involute; anthers yellow.
Septa smooth.
Plant midheight, stems midsize.
Seeds "ecru-olive", small (4.0 to 5.0 mg.).....
TAMMES CRIMPED-WHITE.. 49
Seeds pale-yellow, midsize (5.0 to 6.0 mg.).....OTTAWA 770B.. 49
Plant tall, stems large.
Seeds yellow, small (4.0 to 5.2 mg.).....TALMUNE.. 49
Septa ciliate.
Plant midheight, stems midsize.
Seeds yellow, midsize (5.5 to 6.8 mg.).....CRYSTAL.. 51
Bolls indehiscent, ovoid, large.
Flowers star-shaped.
Petals white, narrow, involute; anthers yellow.
Septa ciliate.
Plant short, stout.
Seeds brown, large (7.5 to 9.0 mg.).....ALBUM, TYPE 13.. 51

DESCRIPTION, HISTORY, AND DISTRIBUTION OF FLAX VARIETIES

NARROWLEAF FLAX

(*Linum angustifolium*)

Description.—Plant short to midheight (10 to 15 in.), annual or winter annual, stems slender, spreading, branching from the crown, leaves small, linear, closely spaced on the stems; bolls dehiscent, small (5 mm. wide by 7 mm. long); septa ciliate; seeds brown, very small; flowers funnelform, small (10 to 13 mm. wide); sepals persistent, ovate, acute, three-veined, with filmlike margins; petals lavender, small (5 mm. wide by 7 mm. long), veins violet; anthers blue; filaments white; style one-third blue.

History.—Two samples of *Linum angustifolium* (C. I. 468 from Tammes and C. I. 698 from Vavilov) were grown.

Distribution.—*L. angustifolium* is native to the Mediterranean area (*37, p. 187*) and has been found adventitious in Douglas County, Oreg., as recorded by Peck (*26*).

DEHISCENT FLAX

(Linum usitatissimum crepitans)

Elladi (*13*) described six varieties of dehiscent flax, subspecies *crepitans*, which are cultivated to a limited extent in the U. S. S. R., Germany, Portugal, and Spain. The dehiscent varieties are readily recognized by their widely dehiscent bolls with smooth septa. The plants are stout, erect, with few or no basal branches. The flowers are small, funnelform; the anthers blue; and the petals lavender with violet veins. The seeds are brown, small to midsize, flat, ovoid, and the beak not prominent. In a letter of April 13, 1933, to the writer, Elladi says: ". . . in the var. *crepitans* the septa of the bolls are always nonciliate."

UCRANICUM

Description.—Plant midheight (18 to 24 in.), usually without basal branches, panicle midspreading, leaves large, rather widely spaced, upper leaves often recurved; bolls dehiscent; septa smooth; seeds brown, small (3.8 to 4.7 mg.), ovoid, not rostellate; flowers funnelform, small (10 to 14 mm. wide); petals small (7 mm. wide by 10 mm. long), lavender, veins violet; anthers blue; pollen light blue; filaments a trace to one-half light violet; style one-half violet blue; stigma lavender to violet.

History.—Five samples of Ucranicum were grown. C. I. Nos. 506 and 507 were received in May 1930, through N. I. Vavilov from the Snovsk District, Ukraine, U. S. S. R., and C. I. Nos. 758 (from Lumsk, Ukraine) and 759 (from Tchernigov, Ukraine) were obtained in May 1933 from Catherine Elladi. These four strains are similar except for some variation in the extent of color in the filaments and styles. C. I. 295 (P. I.[1] 58248) was received in 1923 from T. D. A. Cockerell, University of Colorado, who obtained the seed some 70 miles north of Vladivostok, Siberia. This strain is somewhat taller (24 to 30 in.) than the four strains from Ukraine, the flowers are similar to or identical with them, and the seeds slightly smaller (3.4 to 4.5 mg.).

GERMANICUM

Description.—Plant short to midheight (16 to 22 in.), early; bolls dehiscent, globose; septa smooth; seeds small (4.4 to 5.4 mg.). Germanicum is of shorter habit and earlier in maturity, and has slightly larger bolls and seeds than Ucranicum, and the flowers are similar to or identical with those of the variety Ucranicum.

History.—Germanicum (C. I. 496) (P. I. 76793) was obtained from Tammes in May 1928 and C. I. 760 from Elladi. Both came originally from the Bavarian Woods of southern Germany.

COIMBRICUM

Description.—Plant short (12 to 20 in.), very early; bolls dehiscent, large; septa smooth; seeds brown, midsize (5.3 to 5.7 mg.). Coimbricum is of shorter habit, of earlier maturity, and has larger seeds than Germanicum, and the flowers are similar to or identical with that variety.

History.—Coimbricum (C. I. 761), obtained from Elladi in May 1933, was originally collected by Vavilov near Coimbra, Portugal, and in Galicia, Spain.

Comparisons.—Elladi (*13*) described three additional varieties: Ibericum, which differed from Coimbricum by an intensive purple-colored flower; Vaccaeorum, the plants similar to Coimbricum but with larger seeds (6.7 mg.); and Transiens (C. I. 672), found in Portugal by Vavilov, which had cup-shaped bolls only half-dehiscent, had smooth septa, was late in maturity, and was susceptible to wilt.

Flor (*14*) reported C. I. Nos. 295, 469, 506, and 507 as susceptible to rust, but these selections are moderately wilt-resistant.

[1] P. I. refers to accession number of the Division of Plant Exploration and Introduction.

COMMON FLAX

(Linum usitatissimum)

Indian Varieties

Howard and Khan (*18*), in their description of Indian flaxes, used the color of the petals (corolla), anthers, filaments, and style as key characters to distinguish varieties. The authors describe 123 "types," which they include under 26 Latin varietal names. These varieties represent a fascinating range of petal colors, especially in the hues and tones of blue, violet, mauve, and purple. The number of "types" and varieties selected and named by Howard and Khan (*18*) led Vavilov (*37*) to comment on the great diversity of forms found in India. As a matter of fact, the Indian flaxes represent a comparatively narrow and distinct group of varieties, having little diversity of form. The Indian flaxes are short, rather stout, branched; the bolls indehiscent in most varieties; the seeds brown, midsize or large. It is chiefly in the variety of petal colors that considerable diversity occurs. Among the 123 types described, however, neither the common white nor the common pink flower occurs. The "crimped-white" flower with narrow, white, involute petals and yellow anthers is represented in type 13 var. *Album*, of the narrow-petaled varieties. This is the only variety having pure white petals; the other so-called whites are either very pale blue or pale pink.

It is strange that in their key and description of Indian varieties, Howard and Khan (*18*) failed to make use of the ciliate versus smooth (noneciliate) character of the septum to distinguish otherwise similar varieties or strains.

JALAUM

Description.—Plant short (12 to 16 in.), branched, panicle branches short; bolls indehiscent, ovoid, midsize; septa ciliate; seeds brown, midsize to large (6.5 to 8.0 mg.); flowers tubular, rarely opening to vase-shape, small; petals flat, small (7 mm. wide by 10 mm. long), bluish violet; anthers blue; filaments one-fourth blue; style light blue. A striking characteristic of this variety is the thick, firm sepals that prevent the petals from spreading to form the normal funnelform flower. The flower, therefore, is tubular, and the wilted petals cling to the green bolls for a long time after blossoming. The tubular flower may be of some practical economic importance in that it protects the pollen from premature drying in hot weather. Moreover, very little natural crossing occurs in this type of flower, as reported by Dillman (*10*).

History.—Jalaum (C. I. 156) was a selection from P. I. 36566 (C. I. 21), obtained in 1913 from William Burns, economic botanist for India, who noted, "From United Provinces, Jalaum district." The selection probably was made by Charles H. Clark, of the United States Department of Agriculture, at the Northern Great Plains Field Station, Mandan, N. Dak., in 1914. Seed grown at the Williston substation, Williston, N. Dak., in 1916 was assigned C. I. 156.

Distribution.—Not grown commercially in the United States.

Comparison.—Campestre, type 68, of Howard and Khan (*18*) is similar to Jalaum, except that Campestre, type 68, has smooth septa.

PUNJAB

Description.—Plant short to midheight (15 to 30 in.), stems stout, often with two or more basal branches, panicle spreading, branches midlong; bolls indehiscent, ovoid, midsize; septa ciliate; seeds brown, midsize (5.5 to 6.5 mg.); flowers funnelform, midsize (spread 16 to 18 mm.); petals flax blue; anthers blue; filaments one-third blue; style one-third blue. Plants resistant to rust but susceptible to wilt and pasmo.

History.—Punjab (C. I. 20) was selected by Charles H. Clark, of the United States Department of Agriculture, from P. I. 36565, obtained in 1913 from William Burns, economic botanist for India. Burns noted, "From Punjab, that which is grown after rice crop." Clark made several selections at the Northern Great Plains Field Station, Mandan, N. Dak., in 1914 and reselected in 1915. One of the taller and high-yielding selections was increased and retained under the name "Punjab" (C. I. 20). Punjab was grown in varietal tests at different stations in California and Arizona and at San Antonio, Tex., during the period 1916 to 1920, but it did not become established as a farm crop at that time. The very beginning of flax production in California occurred on November 14, 1927, when L. G. Goar, then superintendent of the Imperial Valley Experiment Station at El Centro, planted seed of 10 varieties in nursery plots. Punjab produced the highest yield—31.2 bushels an acre. After further testing, seed of Punjab was increased in 1930-31 on 2 acres near El Centro. The seed of this crop was distributed to a few farmers in 1932.

Distribution.—Grown extensively as a fall-sown crop under irrigation in California and Arizona.

Comparisons.—Other varieties of Indian origin that may be of value in flax breeding, because of their rust resistance, include Bombay (C. I. 42) and Indian types 29, 46, 48, and 53 of Howard and Khan (*18*). These are resistant to or immune from nearly all races of rust found in North America, according to Flor (*14*).

ALBIDUM, TYPE 12

Description.—Plant short (10 to 15 in.), branched, stems stout, panicle short, compact; bolls indehiscent, ovoid, to semidehiscent, globose; septa smooth; seeds brown, midsize (5.0 to 6.5 mg.); flowers funnelform or vase-shaped, small; petals small (6 mm. wide by 10 mm. long), very pale blue (nearly white), veins indistinct; anthers and pollen cream yellow; filaments white; style white; stigma white. Albidum, type 12, is exceptional among Indian varieties in having nearly semidehiscent bolls.

History.—Albidum, type 12, was selected by Howard and Khan (*18*). It proved to be promising in yield, and seed was increased and released for commercial growing in India, as reported by the authors.

Distribution.—Grown to some extent in India, but not grown commercially in the United States.

COMMUNE, TYPE 55

Description.—Plant short (14 to 18 in.), branched, stems stout; bolls indehiscent, ovoid, midsize; septa smooth; seeds brown, midsize (5.0 to 6.0 mg.); flowers funnelform, midsize; petals bluish violet; anthers blue; filaments one-third light blue; style one-half blue. Plants moderately resistant to wilt but susceptible to rust.

History.—Commune, type 55, is one of the higher yielding types segregated by Howard and Khan (*18*).

Distribution.—Not grown commercially in the United States, but useful in breeding for wilt resistance.

SATIVUM, TYPE 121

Description.—Plant short (12 to 16 in.), erect, stems stout, panicle branches short, forming a close panicle; bolls indehiscent, ovoid, midsize; septa smooth; seeds brown, midsize; flowers vase-shaped, small (8 to 10 mm. wide); petals small (6 mm. wide by 10 mm. long) but overlapping, violet, fading to lavender, veins purple; anthers blue; filaments one-third blue; style one-half blue. The flower buds are slow to open, and the wilted petals usually cling to the green bolls.

History.—Sativum, type 121, was selected by Howard and Khan (*18*) and grown commercially in India.

Distribution.—Not grown in the United States.

Mediterranean Varieties

The Mediterranean flaxes represent a distinct group. Vavilov (*37*) described the flaxes of Morocco, Algeria, Tunis, Palestine, and Egypt

as having large seeds, large flowers (up to 28 mm. wide), and large indehiscent bolls that are difficult to thresh. They occur, also, on the islands of Cyprus, Crete, and Sicily. The plants are short to midheight, but taller than the Indian flaxes; the stems stout, often with two or more basal branches; the leaves large and relatively widely spaced. The flowers are large, broadly funnelform; the bolls indehiscent, ovoid, large, or in some strains nearly semidehiscent; the septa ciliate; and the seeds brown, large to very large (6.5 to 11.0 mg.). Most strains are early to midseason in maturity, resistant or immune to rust, but susceptible to wilt. Five varieties, typical of this group, are described. Other varieties that may be included in this group are Smyrna (C. I. 30), Crete (C. I. 31), and Moose (C. I. 704–5) obtained from New Zealand.

CYPRUS

Description.—Plant short (14 to 20 in.), with few or no basal branches; bolls indehiscent, ovoid, large; septa ciliate; seeds brown, large to very large (7.5 to 11.0 mg.); flowers broadly funnelform, large (18 to 24 mm. wide); petals large (11 mm. wide by 13 mm. long), flax blue, veins violet; anthers blue; filaments trace of blue; style trace to one-third blue; stigma white or lavender. Flower parts are somewhat variable. About 50 percent of plants immune to rust; all susceptible to wilt.

History.—Seed of Cyprus (C. I. 689) was obtained in 1931 from O. S. Aamodt, head of the Division of Field Husbandry, of Alberta, Canada. The original seeds (C. A. N.[5] 2110) were obtained in 1927 from the island of Cyprus by the Central Experimental Station, Ottawa, Canada.

Distribution.—Not grown commercially in the United States.

MOROCCO

Description.—Plant short to midheight (15 to 26 in.), with few or no basal branches; bolls indehiscent, ovoid, large; septa ciliate; seeds brown, large (6.6 to 9.5 mg.); flowers broadly funnelform, large (20 to 25 mm. wide); petals large (11 mm. wide by 13 mm. long), partly separate, flax blue, veins violet; anthers blue; filaments white; style trace of blue; stigma white or lavender. Plants immune to rust and somewhat wilt-resistant.

History.—Seed of Morocco (C. I. 376) was obtained in 1926 from the Ministry of Agriculture, El Giza, Egypt, with the note, "an oil flax obtained through the courtesy of Mr. Bateson." The selection, No. 376-2, is typical of the variety.

Distribution.—Not grown commercially in the United States.

LINO GRANDE

Description.—Plant short (15 to 20 in.), with few or no basal branches, panicle somewhat open, stems midsize, stout; bolls indehiscent, ovoid, large; septa ciliate; seeds brown, large to very large (7.5 to 10.6 mg.); flowers broadly funnelform, large (20 to 28 mm. wide); petals broadly oval, large (12 mm. wide by 14 mm. long), overlapping, flax blue, veins violet; anthers blue; filaments white; style white; stigma white or lavender. The selection 381-2 is resistant or immune to rust and somewhat wilt-resistant.

History.—Seed of Lino Grande (C. I. 381) was obtained in 1926 from Argentina, where it was then grown commercially to a limited extent. In a letter of November 25, 1926, Mr. Carlos D. Girola says: "The lino grande (big flax) is regarded as having its origin from the south of Italy."

Distribution.—Not grown commercially in the United States.

Comparison.—Norsk (C. I. 889), a variety very similar to Lino Grande, was obtained from Norway by O. E. Heggeness, North Dakota Agricultural Experiment Station, Fargo. Norsk is grown to a limited extent in southern Texas.

[5] C. A. N.=Canadian accession number.

BELADI

Description.—Plant midheight (16 to 24 in.), with few or no basal branches, panicle branches long, spreading, forming an open panicle (fig. 10, *A*); bolls indehiscent, ovoid, large, very firm, and hard; septa ciliate; seeds brown, large (7.0 to 8.4 mg.), beak not prominent; flowers funnelform, large (18 to 25 mm. wide); petals large (11 mm. wide by 13 mm. long), flax blue, veins violet; anthers blue; filaments two-thirds violet blue; style one-half blue; stigma lavender to violet. Plants resistant or immune to rust but very susceptible to wilt.

History.—Beladi (C. I. 377–1) was obtained from the Ministry of Agriculture, El Giza, Egypt, in 1926, with the note, "Native flax used for both seed and fiber." The original seed was not uniform. The selection 377–1 was increased and is the one described above. It is typical of the variety, which has exceptionally firm bolls. Beladi is not a productive variety, its yield always being relatively low. The name, pronounced Bel-a-di, is Egyptian, meaning local or common.

Distribution.—Grown to some extent in Egypt.

GIZA

Description.—Plant midheight (16 to 30 in.), with few or no basal branches; bolls indehiscent, ovoid, large; septa ciliate; seeds brown, very large (9.0 to 10.6 mg.); flowers funnelform, large (20 to 25 mm. wide); petals large (11 mm. wide by 14 mm. long), flax blue, veins violet; anthers blue; filaments trace of light blue; style one-third blue; stigma lavender. Plants immune to rust but susceptible to wilt.

History.—Seed of Giza (C. I. 378) was obtained in 1926 from the Ministry of Agriculture, El Giza, Egypt. It was selected there as "a rogue or sport found in Normandy flax." This variety yields well as a fall-sown crop under irrigation in California. Its large seeds have a high percentage of oil.

Distribution.—Not grown commercially.

Argentine Varieties

The commercial flaxes of Argentina represent a group that can be distinguished readily from the Indian flaxes and from the commercial flaxes of the United States and Canada. They are more like the large-seeded Mediterranean flaxes. In a letter of November 25, 1926, Carlos D. Girola stated: "Flax was first introduced from Spain perhaps as early as 1800, and later from Italy, France, and Russia." It was not, however, until about 1880 that the flax crop became of commercial importance, but in the 1930's Argentina produced a large part of the world supply of flaxseed. The Argentine flax known as Malabrigo, named from the village of Mal Abrigo in Santa Fe, should be considered a commercial type rather than a pure-line variety. It seems likely that it was developed through a long period of natural selection and adaptation as a fall-sown or "winter crop" in the State of Santa Fe.

Comparative tests (*10*) indicate that Rio (C. I. 280), a selection of Argentine flax, is more cold-resistant than Bison, Redwing, and certain fiber varieties, at least in the seedling and early-growth stages. The plants branch freely at the crown and their growth is relatively slow when sown in the fall. Experimental and field tests in southern Texas have shown that there is a real difference in the cold resistance of flax varieties, although the range in cold tolerance probably does not exceed 5° F. This difference, however, may often determine the survival of a variety as a fall-sown crop.

As flax is an important crop in Argentina and Uruguay, extensive breeding and selection work has been carried on at the several experi-

mental stations during recent years. The new strains that are grown commercially include No. 330 M. A. (Ministry of Agriculture, Argentina) (C. I. 867), a selection of Malabrigo developed at the Pergamino station; Klein 11 (C. I. 869), a selection of Malabrigo developed by E. Klein; Repetible No. 30/33 (C. I. 790), a selfed line of Malabrigo developed by Albert Boerger at "La Estanzuela," Colonia, Uruguay.

In this bulletin five varieties of the Argentine group and two varieties of hybrid origin are described.

RIO

Description.—Plant midheight (18 to 26 in.), often with two or more basal branches, stems stout; bolls indehiscent, ovoid, midsize; septa ciliate; seeds brown, large (6.0 to 8.3 mg.); flowers broadly funnelform to diskform, large (22 to 28 mm. wide); petals flax blue with violet veins, large (11 mm. wide by 14 mm. long); anthers blue; pollen pale blue; filaments white; style white or rarely having a trace of blue; stigma white or lavender; midseason to late in maturity. Rio is immune to forms of rust found in the United States (*15*) but is susceptible to rust in Argentina, as reported by Vallega (*36*). It is wilt-resistant but susceptible to pasmo.

History.—Rio (C. I. 280) is a selection (Long No. 79) from commercial Argentine flax made by H. D. Long in 1918 at the North Dakota Agricultural Experiment Station and distributed by H. L. Bolley in 1923. The name "Rio" was proposed by Dillman (*8*).

Distribution.—Grown in Texas and California.

MALABRIGO

Description.—Plant midheight (18 to 25 in.), stems stout; bolls indehiscent, ovoid, midsize; septa ciliate; seeds brown, large (6.0 to 8.5 mg.); flowers broadly funnelform to diskform, large (22 to 26 mm. wide); petals flax blue, veins violet; anthers blue; filaments white; style one-fourth blue; stigma white or lavender. Malabrigo is wilt-resistant and immune to rust; very similar to Rio except the style is partly blue.

History.—Malabrigo (C. I. 696) is a pure-line selection from Malabrigo made by the writer at St. Paul, Minn., in 1925. The variety Malabrigo has been obtained from Argentina at different times, samples being recorded under C. I. Nos. 345, 346, 347, and 872. As already mentioned, Malabrigo is the prevailing commercial type in Argentina. In 1930-31, Bolley (*5*) collected some 400 samples of flaxseed in Argentina and nearly all of the commercial samples, approximately three-fourths of the total number, proved to be of the Malabrigo type when grown at Fargo, N. Dak., and at San Antonio, Tex.

Distribution.—Formerly grown extensively in Argentina, now being replaced by selected varieties of similar type, such as Querandi M. A., 330 M. A., La Prevision 18, Repetible 30/33, and Klein 11.

Comparison.—Calar (C. I. 463), a selection of Malabrigo type made by the writer, is grown to some extent in California.

KLEIN 11

Description.—Plant midheight (16 to 24 in.); bolls indehiscent, ovoid, midsize; septa ciliate; seeds brown, midsize to large (6.0 to 7.0 mg.); flowers broadly funnelform to diskform, large (22 to 25 mm. wide); petals light blue, veins violet, midsize (9 mm. wide by 12 mm. long), partly separate; anthers blue; filaments white; style trace to one-third blue; stigma lavender. Plants resistant or immune to rust, but somewhat susceptible to wilt. Klein 11 can be distinguished from Rio and Malabrigo by its light-blue flower in which the petals are partly separate instead of overlapping.

History.—Klein 11 is a selection from Malabrigo made by E. Klein, a private plant breeder of Argentina, in 1920.

Distribution.—According to Jose Vallega (*36*), this variety is grown commercially to a considerable extent in Argentina.

RIGO

Description.—Plant midheight (16 to 24 in.), midseason, with two or more basal branches, stems stout; bolls indehiscent, ovoid, midsize; septa ciliate; seeds brown, large (6.5 to 8.0 mg.); flowers diskform, large (22 to 26 mm. wide); petals large, flat, "pale verbena violet," veins violet; anthers blue; filaments white; style white; stigma white. Plants resistant to wilt and rust.

History.—Rigo (C. I. 690) is a selection from Malabrigo made by the writer at St. Paul, Minn., in 1925. It is a uniform and productive variety. At Bozeman, Mont., the yields in three-row triplicate plots ranged from 22.0 to 36.4 bushels an acre during the 5-year period 1933–37, and averaged 28.0 bushels an acre as compared with 24.0 bushels for Bison. The large, "pale verbena violet" flower, with blue anthers and white filaments and style is very distinctive.

Distribution.—Not grown commercially.

LIGHT MAUVE

Description.—Plant midheight (20 to 24 in.), midseason, stems stout; bolls indehiscent, ovoid, midsize; septa ciliate; seeds brown, midsize to large (5.5 to 7.8 mg.); flowers broadly funnelform to diskform, large (22 to 26 mm. wide); petals "light mauve," veins reddish violet, large (11 mm. wide by 13 mm. long), overlapping; anthers blue; filaments white; style white; stigma white. Plants resistant to rust and moderately wilt-resistant but susceptible to pasmo.

History.—Light Mauve (C. I. 379–1) is a selection made by the writer in 1927 at University Farm, St. Paul, Minn., from a sample of seed obtained from the Ministry of Agriculture, El Giza, Egypt. This seed was labeled "Bombay," but the plants were of typically Argentine type, not Indian type. The name "Light Mauve" was suggested by the writer, because of the distinct petal color.

Distribution.—Grown to a limited extent in Texas.

Argentine Hybrids

Certain varieties, originating as natural hybrids or as crosses with Argentine flax, are much like the Argentine flax in plant and flower characters, except that the bolls are semidehiscent. Two varieties in this group are described.

B–5128

Description.—Plant midheight (18 to 30 in.), midseason to late, stems stout; bolls globose to ovoid, slowly semidehiscent, large; septa ciliate; seeds brown, midsize (5.5 to 7.0 mg.); flowers broadly funnelform, midlarge (20 to 24 mm. wide); petals light blue, veins violet, midsize (10 mm. wide by 12 mm. long); anthers blue; pollen pale blue; filaments white; style white or trace of blue; stigma lavender to violet. Plants are resistant to rust and wilt but susceptible to pasmo. A high-yielding variety, having many characters common to the Argentine type, B–5128, can be identified in flower by a rare character—the anthers extend somewhat above the stigma.

History.—B–5128 (C. I. 980) was selected by H. L. Bolley and O. E. Heggeness from a cross of Golden by Rio made by Heggeness in 1930. The Golden parent was selected from a cross of unknown history made by H. D. Long some years earlier. B–5128 was increased from a selection made in the F_5 generation. It was included in uniform regional tests from 1939 to 1941, where it was outstanding in yield. Seed was increased by the North Dakota Agricultural Experiment Station and released to farmers in 1943.

Distribution.—Grown widely in eastern North Dakota and to some extent in Minnesota and South Dakota and as a fall-sown crop in southern Texas.

WALSH

Description.—Plant midheight (18 to 26 in.), early to midseason, stems stout; bolls semidehiscent, globose, large; septa ciliate; seeds brown, large (7.5 to 9.5 mg.); flowers broadly funnelform, large (22 to 28 mm. wide); petals large (12 mm. wide by 14 mm. long), flax blue, veins violet; anthers blue; filaments

white; style white or with a trace of blue; stigma lavender. Plants mostly immune to rust and moderately wilt-resistant.

History.—Walsh (C. I. 645) is a selection by H. D. Long at the North Dakota Agricultural Experiment Station. In a letter of May 7, 1931, Mr. Long wrote: "This variety is the result of a number of crosses including N. D. R. 52, Argentine, a fiber flax, and a sample of Guatemala seed." Seed was first distributed in 1931 and grown commercially to some extent in Walsh County, N. Dak. The large seeds contain a high percentage of oil, but the variety is not highly productive under conditions of high temperatures. In plot tests at Fargo, N. Dak., the average yield of Walsh for the 8-year period, 1931–38, was 13.8 bushels per acre, as compared with 16.1 bushels for Bison.

Distribution.—Grown widely in North Dakota and Montana because of its rust resistance. Also grown in New Zealand.

Golden Varieties

A unique group of flaxes are the so-called Golden varieties. These have pale-pink petals, yellow anthers, and pale yellow, chamois-yellow, mottled, or "mummy-brown" seeds. The anthers are always yellow. In varieties with very pale-pink petals the flowers are often called white, but they are genetically distinct from the true white-flowered varieties. The pink tint of the petals, usually with distinct violet veins, can be distinguished in the flower buds about to unfold. Five varieties in this group are described.

HOSHANGABAD

Description.—Plants short (12 to 20 in.), usually with two or more basal branches, panicle branches long, forming a bushy type of plant, stems stout; leaves large, widely spaced; bolls indehiscent, ovoid, large; septa ciliate; seeds pale yellow, very large (9.4 to 10.6 mg.); flowers funnelform, midsize (15 to 18 mm. wide); petals flat, midsize (11 mm. wide by 13 mm. long), very pale pink, veins violet, very distinct; anthers yellow; filaments a trace to one-third violet blue; style one-half blue; stigma white. The large seeds contain a high percentage of oil but are often low in germination, resulting in thin stands.

History.—Seed of Hoshangabad (C. I. 40) was first obtained in February 1914 from Hoshangabad, Central Province, India, through A. Howard, Imperial Economic Botanist for India. Later, in February 1918, an identical variety was obtained from Luther Burbank under the name "Burbank" (C. I. 166). Both C. I. 40 and C. I. 166 appear to be identical with Luteum, type 1, described by Howard and Khan (*18*). The writer also has found seeds of this variety in commercial Indian seed C. I. 781–C.

Distribution.—Formerly grown under the name "Burbank." Not grown commercially in the United States at present, as it is very susceptible to wilt, rust, and other flax diseases.

Synonyms.—Burbank; Luteum, type 1 (*18*).

BOLLEY GOLDEN

Description.—Plant short to midheight (16 to 28 in.), early, usually with two or more basal branches, stems stout; bolls indehiscent, ovoid, to semidehiscent, globose, midsize; septa ciliate; seeds yellow, midsize (5.5 to 7.0 mg.); flowers funnelform, midlarge (20 to 24 mm. wide); petals midsize (10 mm. wide by 12 mm. long), pale pink, veins light violet; anthers light yellow; filaments white; style white; stigma white. Plants immune or resistant to rust and moderately resistant to wilt but very susceptible to pasmo (fig. 15).

History.—Bolley Golden (C. I. 644) is a selection of unknown hybrid origin. Seed obtained in 1930 from the North Dakota Agricultural Experiment Station as N. D. 40041.

Distribution.—Bolley Golden and Viking are grown to some extent in North Dakota, Montana, South Dakota, and Canada; and as a fall-sown crop in southern Texas under the name "Golden."

Synonym.—B. Golden.

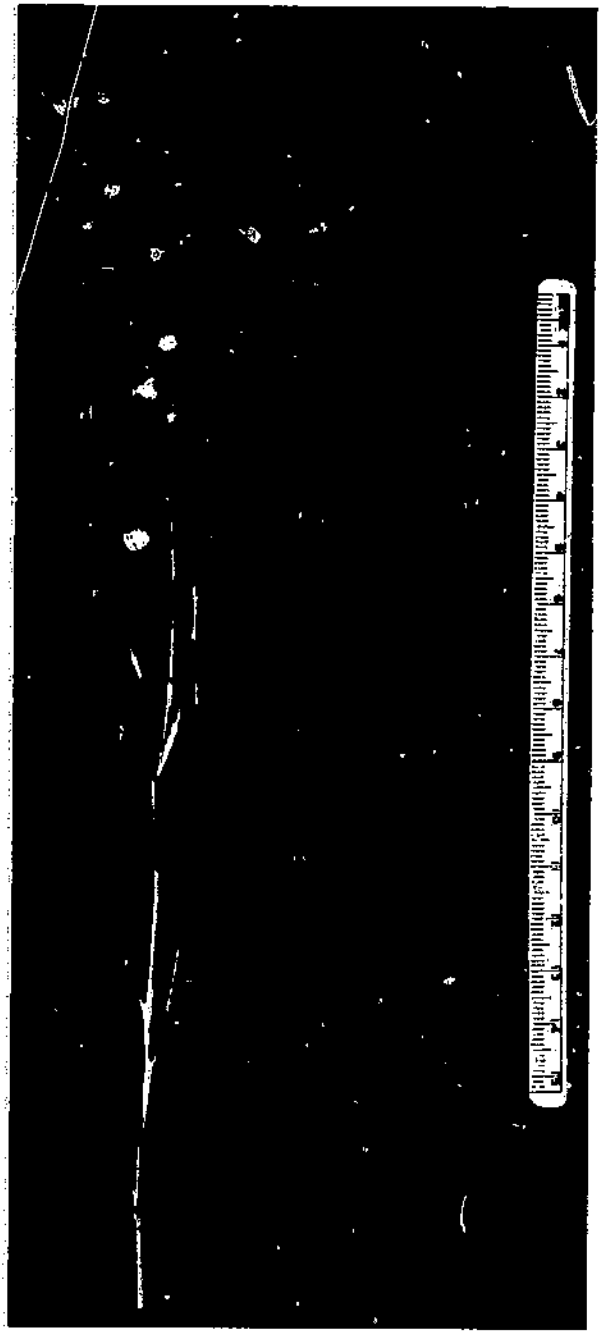

FIGURE 15.—Panicle of Bolley Golden.

Comparisons.—Long Golden (C. I. 735) developed by H. D. Long, Park River, N. Dak., is similar to Bolley Golden. This was first released to farmers in 1930, and in 1932 some 400 acres were inspected for seed certification by the North Dakota Seed Department.

Viking (C. I. 981) was selected by O. E. Heggeness from a cross of Burbank by Bolley Golden. It is very similar to Bolley Golden. Seed of Viking was released to a farmer who increased it to 1,000 bushels in 1938. This seed was purchased by a commercial seed company in Minneapolis, Minn., and distributed to farmers chiefly in North Dakota, where it was grown widely for several years. The variety is very susceptible to pasmo.

Deoro (C. I. 977) (N. Dak. 35221) was selected at the North Dakota station by T. E. Ston about 1930. The name Deoro (Spanish for "of gold") was proposed by the writer. It was grown in the uniform regional tests in the North Central States and Canada from 1939 to 1942, and in nursery tests at Kenedy and Beeville, Tex., from 1947 to 1950.[6] In these tests Deoro yielded slightly more than Bolley Golden. Deoro is 2 to 4 inches taller and about 3 days later in ripening than Bolley Golden and the seeds are slightly smaller.

Deoro was first grown under irrigation in Williams County, N. Dak., about 1944. About 800 to 1,000 acres were sown in the fall of 1949 in southern Texas where some 45,000 acres were harvested in 1952.

REBU

Description.—Plant short to midheight (16 to 24 in.), with two or more basal branches, stems stout; bolls indehiscent, ovoid, midsize; septa ciliate; seeds pale yellow, midsize (5.5 to 7.2 mg.); flowers funnelform, midsize (20 to 24 mm.); petals broad (11 mm. wide by 12 mm. long), overlapping, pale to light pink, veins light violet; anthers light yellow; filaments white; style a trace to one-third blue; stigma white. Plants rust-resistant and somewhat wilt-resistant. The seeds yield a high percentage of oil of good drying quality (Iodine No. 181 to 195).

History.—Rebu (C. I. 649) is a selection from a cross of Rio × Burbank, made by the writer at Mandan, N. Dak., in 1925. A. C. Arny used C. I. 649 in a cross and backcross with Bison (649 × Bison) to produce Minerva, a variety of high oil content.

Distribution.—Not grown commercially.

LETHBRIDGE GOLDEN

Description.—Plant short to midheight (15 to 26 in.), usually with two or more basal branches, panicle branches midlong, forming a broad top, stems stout; bolls indehiscent, ovoid, large; septa smooth; seeds chamois yellow, midsize (4.5 to 7.0 mg.); flowers funnelform, large (22 to 26 mm.); petals large (11 mm. wide by 14 mm. long), partly separate, pale pink, veins distinctly violet at base of petal; anthers salmon yellow, pollen orange yellow; filaments white; style white or with trace of blue; stigma white. Somewhat variable in flower characters and probably not genetically pure. Lethbridge Golden is susceptible to wilt and about 10 percent of plants, according to Flor (7), is resistant or immune to rust.

History.—Seed of Lethbridge Golden (C. I. 23) received in 1913 from the Dominion Experiment Station, Lethbridge, Alberta, Canada. The Dominion station obtained the seed from C. L. Kane, Lethbridge, who obtained his seed from a brother at Conrad, Pondera County, Mont. Two very similar strains were obtained from other sources. Dakota Golden (C. I. 9) was obtained in 1912 from C. F. Hendrickson, Portland, Oreg. Williston Golden (C. I. 25) was obtained in 1911 from a farmer near Williston, N. Dak. The three lots were similar, but all showing some variation in plant and flower characters.

Distribution.—Not grown commercially.

SMOKY GOLDEN

Description.—Plant midheight (18 to 24 in), early, stems stout; bolls indehiscent, ovoid, to slightly semidehiscent, midsize; septa smooth; seeds mottled

[6] Although classification data were completed in 1946, additional information regarding certain varieties has been supplied when available.

or "Isabella" color (*29, pl. 30, 19"i*), midsize (5.5 to 7.0); flowers funnelform, midsize (18 to 22 mm. wide); petals midsize (10 mm. wide by 12 mm. long), pale pink, veins violet; anthers light yellow; filaments white; style white. Plants resistant to rust and moderately resistant to wilt.

History.—Smoky Golden (C. I. 736) was selected by H. L. Bolley and O. E. Heggeness at the North Dakota Agricultural Experiment Station from a cross, (Golden × N. D. R. 52) × Argentine, made by H. D. Long in 1919. In yield it is inferior to Bolley Golden.

Distribution.—Grown to a limited extent in North Dakota.

Winter Varieties

A small group of flaxes can be recognized by their distinct winter habit when fall-planted in a mild climate. The plants branch freely from the crown, the stems are decumbent during the winter period, and the plants are exceptionally cold-tolerant. Two varieties, Roman Winter and Turkey, are described.

At College Station and Kenedy, Tex., Roman Winter and Turkey have endured temperatures as low as 5° F. without injury. The decumbent growth is evidently associated chiefly with day length, and little or not at all with temperature. At Kenedy, the plants are decumbent during long periods of warm weather from November to mid-February, when such varieties as B–5128, Golden, and Dakota make their usual upright growth and even blossom in late January. In late February the stems of winter varieties turn upward at or near the crown, the stems soon become erect, grow rapidly in height, and by mid-March are in full bloom.

ROMAN WINTER

Description.—Plant midheight, branching freely from the crown, midseason to late, stems small to midsize; bolls semidehiscent, subglobose, small; septa ciliate; seeds brown, small (3.5 to 4.0 mg.); flowers funnelform, midsize; petals flax blue, veins violet; anthers blue; filaments white to one-third blue; style one-half blue. Plants somewhat resistant to rust and wilt. Plants of more or less "winter habit," spreading or decumbent when fall-sown and resistant to cold (*10*). Roman Winter grown at Arlington, Va., during the winter of 1939–40 was the only variety that survived (fig. 16).

History.—Seed of Roman Winter (C. I. 470) was obtained from Tammes in 1928 and grown in the classification nurseries several years.

Distribution.—Grown in Italy and southern Germany to a limited extent as a fall-sown crop (*21*), not grown commercially in the United States.

TURKEY

Description.—Plant of distinct winter habit, branching freely from the crown, stems decumbent in early growth, midsize, stout; bolls semidehiscent, subglobose to globose, midsize; septa ciliate; seeds brown, midsize (4.0 to 6.0 mg.); flowers funnelform, midsize; petals flax blue, veins violet; anthers blue; filaments and style about one-third blue. Turkey is exceptionally cold-tolerant. Because of the long growing season required, Turkey flax should be planted in November. It is not adapted to late winter or spring planting.

History.—Seed of Turkey (C. I. 862) was obtained by H. L. Westover of the United States Department of Agriculture from the vicinity of Karacabey, Turkey, in 1937. The seed was planted for observation and increase at the Montana Agricultural Experiment Station, Bozeman, Mont., and later released for trial at College Station, Tex. E. S. McFadden of the United States Department of Agriculture made several winter-hardy selections of similar type and grew these for observation and yield tests. Later, three or four of the higher yielding and hardy strains were bulked under the name Turkey. This seed was increased by Walter Cardwell, Superintendent, Luling Farm Foundation, Luling, Tex., in 1946–47 and later released to growers in southern Texas.

Distribution.—Grown in southern Texas as a winter crop.

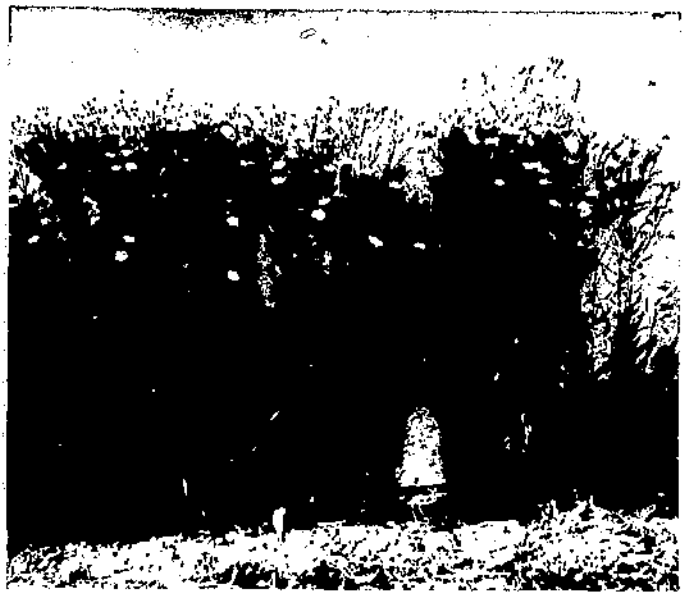

FIGURE 16.—Roman Winter flax grown at Arlington, Va., in 1939–40. Photographed June 3, 1940.

ABYSSINIAN VARIETIES

The Abyssinian flaxes represent a distinct group. The plants are short, much-branched, and the stems fine and very leafy. Two varieties, Abyssinian Yellow-seed and Abyssinian Brown, are described. Both have flax-blue petals. The writer suggests that the small yellow seeds of Abyssinian Yellow-seed would be very attractive and suitable for the drug trade and possibly also as a substitute for sesame seed in the baking industry.

ABYSSINIAN YELLOW-SEED

Description.—Plant short (12 to 20 in.), much-branched, early to midseason, stems small, leaves small and closely spaced; bolls semidehiscent, subglobose to globose; septa smooth; seeds clear yellow, small (4.0 to 5.0 mg.), beak prominent; flowers funnelform, midsize; petals flax blue; anthers blue; filaments a trace of blue; style three-fourths violet blue; stigma purple. Plants susceptible to rust and wilt.

History.—Abyssinian Yellow-seed (C. I. 36) was selected from a mixed lot of seed obtained from Addis Ababa, Abyssinia, in 1914. It was grown experimentally for several years and was rather promising as a fall-sown crop under irrigation in California, except that the seeds shattered to some extent when harvest was delayed.

Distribution.—Formerly grown to a limited extent in California and Texas.

ABYSSINIAN BROWN

Description.—Very similar to Abyssinian Yellow-seed except that the seeds are brown.

History.—Abyssinian Brown (C. I. 302) was selected from a lot of mixed seed obtained by H. V. Harlan at Addis Ababa, Abyssinia, in 1924.

Distribution.—Grown in Abyssinia as an oilseed crop. Most commercial samples are a mixture of brown and yellow seeds. Abyssinian Brown is not grown in the United States.

North American Seed-Flax (Linseed) Varieties

The North American seed-flax varieties are grown for seed (linseed) in the North Central States and Canada. A few older varieties of historical importance; new varieties developed by crossing followed by intensive selection and testing for disease resistance, yield, and quality of oil; and certain white-flowered, brown-seeded varieties of similar plant type are included in this group.

FRONTIER

(Type Variety)

Description.—Plant midheight (20 to 26 in.), stems midsize; bolls semidehiscent, subglobose to globose; septa smooth; seeds brown, small (4.5 to 5.5 mg); flowers funnelform, midsize (15 to 18 mm. wide); petals flax blue; anthers blue; filaments and style white to one-fourth light blue. Plants susceptible to wilt and rust.

History.—Frontier (C. I. 17) (N. Dak. 155) was obtained by the Agronomy Department of the North Dakota Agricultural Experiment Station from a commercial seed company in 1898. It was typical of the so-called Russian, or common, seed flaxes obtained from the Ukraine of southern U. S. S. R. during the period 1870 to 1900.

Distribution.—Formerly grown extensively on new lands in North Dakota, South Dakota, and Montana from 1910 to 1925, but later replaced by wilt-resistant varieties.

Comparisons.—Clark (7) listed several so-called varieties that were very similar to Frontier in type of plant, yield, and disease reaction. These include Select Russian (C. I. 1), Select Riga (C. I. 2), Damont (C. I. 3), Stephan (C. I. 5), and Reserve (C. I. 19). N. D. R. 52 (C. I. 8) and N. D. R. 73 (C. I. 14), two of H. L. Bolley's earlier selections, were somewhat resistant to wilt but otherwise were similar to Frontier. Bush (C. I. 419) also belongs to this group. Bush was selected in 1920 from a field of common flax by John F. Schoof, Gettysburg, S. Dak., who increased it and offered seed for sale in 1928. In tests at the Northern Great Plains Field Station, Mandan, N. Dak., in 1928, Bush flax was susceptible to wilt and to rust. It was similar to or identical with Frontier. Flaxes of this common- or Russian-type were grown extensively on new lands in North Dakota, South Dakota, and Montana from 1890 to 1920, but now have been largely replaced by wilt-resistant varieties.

NEWLAND

Description.—Plant midheight (24 to 28 in.), early to midseason, panicle open, spreading, stems midsize; bolls semidehiscent, subglobose to globose; septa smooth; seeds brown, small (4.5 to 5.5 mg.); flowers funnelform, midsize; petals flax blue; anthers blue; filaments trace of blue; style one-third blue. Plants susceptible to wilt but immune to most North American races of rust as reported by Flor (*14*).

History.—Newland (C. I. 188) is a selection from Reserve (C. I. 19) made by C. H. Clark, at the Northern Great Plains Field Station, Mandan, N. Dak., in 1914. It was grown in varietal tests at the Judith Basin Experiment Station, Moccasin, Mont., from 1921 to 1926, where it was outstanding in yield. Seed was increased and released to farmers by the Montana Agricultural Experiment Station in 1926.

Distribution.—Formerly grown extensively in Montana for several years but finally replaced by Bison. Newland has been used as a parent in breeding for rust resistance.

RENEW

Description.—Plant midheight (20 to 28 in.), early, panicle branches midlong, spreading, stems midsize, stout, rarely lodging; bolls semidehiscent, subglobose to globose; septa smooth; seeds dull brown, midsize (4.5 to 6.0 mg.); flowers funnelform, midsize (16 to 20 mm. wide); petals flax blue; anthers blue; filaments white; style about one-third light blue. Plants resistant to rust and moderately resistant to wilt but susceptible to pasmo. Renew flaxseed can be

usually distinguished by its dull-brown tone in contrast to the bright brown of such varieties as Koto, Bison, Arrow, and Dakota.

History.—Renew (C. I. 839) is a selection from a cross, Newland × (Reserve × Morye, C. I. 112). The cross was made by J. C. Brinsmade, Jr., at the Northern Great Plains Field Station, Mandan, N. Dak., in 1930. Selections made in 1934 were grown in triplicate 5-foot rows on wilt-infested soil in 1935. One of the wilt-resistant selections (row 686) was assigned C. I. 839 and later named Renew. In regional varietal experiments Renew proved to be well adapted to dry-land conditions in the northern Great Plains. Seed was increased by T. E. Stoa at the North Dakota station and released to farmers in 1942.

Distribution.—Formerly grown extensively in western North Dakota and eastern Montana.

DAKOTA

Description.—Plant midheight (20 to 28 in.), early to midseason, stems midsize, stout, rarely lodging; bolls semidehiscent, subglobose to globose; septa smooth; seeds bright brown, midsize (5.0 to 6.5 mg.); flowers funnelform, midsize; petals flax blue; anthers blue; filaments white; style about one-half violet blue. Plants resistant to rust and wilt. Dakota is somewhat shorter and slightly earlier than Arrow, Koto, and Bison, and the septa of the bolls are smooth instead of ciliate as in Arrow, Koto, and Bison.

History.—Dakota (C. I. 1071) is a selection from a cross, Renew × Bison. It has the same early history of development as Arrow. Dakota was increased from selection D41–106 grown at Fargo in 1941. In 1942, it was grown in replicated nursery plots at Bozeman, Mont., Fargo, N. Dak., and St. Paul, Minn. It was outstanding in yield. The seed was increased at El Centro, Calif., in 1942–43, and at Fargo in 1943 and 1944. In 1945, 60 acres grown under contract by two farmers in Cass County, N. Dak., produced 1,000 bushels of seed. This foundation seed was released to growers of certified seed in North Dakota, Minnesota, and South Dakota, for growing in 1946.

Distribution.—Grown extensively in North Dakota, South Dakota, Minnesota, Kansas, Iowa, and Montana, and in Canada.

Note.—Soon after its introduction in 1949 a new race of rust appeared to which Dakota was susceptible. This rust spread rapidly and did much damage to fields of Dakota flax in 1951.

OTTAWA WHITE-FLOWERED

(Type Variety)

Description.—Plant midheight (20 to 28 in.), slender, early to midseason, panicle midlong, stems midsize; bolls semidehiscent, subglobose; septa smooth; seeds brown, small to midsize (3.5 to 4.8 mg.); flowers funnelform, midsize (14 to 17 mm. wide); petals white, without colored veins; anthers and pollen blue; filaments white; style white; stigma white to lavender.

History.—Ottawa white-flowered (C. I. 24) (C.A.N. 2232) was obtained in 1913 from the Dominion Experiment Station, Indian Head, Saskatchewan, Canada, where the variety had been grown for 10 years. The original seed probably was obtained from the Central Experimental Farm at Ottawa.

Distribution.—Not grown commercially.

Comparison.—Several similar strains of this white-flowered type have been obtained from different sources and grown in the classification nurseries. They differ somewhat in height, yield, and seed size. Most or all are susceptible to wilt and rust. All are early to midseason in maturity. They differ from the white-flowered fiber varieties in being shorter and more productive in yield of seed. Strains of this type include C. I. 509 from Pskov Province and C. I. 510 from Tver Province, U. S. S. R., the seeds of which were obtained in 1930 from N. I. Vavilov; C. I. 399 (N. D. R. 714) obtained from H. L. Bolley; and C. I. 711, obtained in 1931 from the Division of Plant Pathology and Botany, University Farm, St. Paul, Minn. In C. I. Nos. 399 and 711 the bolls have ciliate septa.

VICTORY

Description.—Plant midheight (18 to 30 in.), midseason to late, stems midsize, stout, panicle spreading; bolls semidehiscent or nearly indehiscent, globose; septa smooth (not uniform) or ciliate; seeds brown, large (6.0 to 8.0 mg.);

flowers broadly funnelform, midsize (18 to 22 mm. wide); petals flat, large, white without colored veins; anthers blue; filaments white; style white. Plants moderately resistant to wilt, highly resistant to rust, but rather susceptible to pasmo (fig. 17).

History.—Victory (C. I. 1045) was developed by H. L. Bolley and O. E. Heggeness, Division of Botany and Plant Pathology, of the North Dakota Agricultural Experiment Station. According to Heggeness, Victory was selected from a cross (Czech × Argentine) × Smoky Golden. A selection (B–5585), made from the F_2 generation, was increased, and in 1940 Bolley gave 15 pounds of seed to Fred W. Muscha, Enderlin, N. Dak., for trial. Mr. Muscha increased the seed, and in 1942 he planted 12 acres that produced about 240 bushels of seed. The outstanding rust resistance of Victory was demonstrated in this field, which yielded 20 bushels per acre as compared with an adjoining field of Bison that was severely rusted and produced only 5 bushels an acre. The seed was increased further by growing a winter crop in southern Texas in 1942–43, and this seed was planted as a summer crop in North Dakota for the 1943 harvest. The name Victory was suggested by Mr. Muscha. Victory also was increased by the Division of Agronomy of the North Dakota station and released to farmers for growing as certified seed. From the crop of 1944, 4,082 acres were certified for seed. Victory is fairly uniform in type of flower (white petals and blue anthers), but the plants are variable in height, maturity, and seed size. The seed yields a high percentage of oil of good drying quality.

Distribution.—Grown extensively in North Dakota and South Dakota and to some extent in Minnesota, Montana, and Canada.

DIADEM

Description.—Plant midheight (19 to 24 in.), midseason, panicle branches midlong, spreading, stems midsize, stout; bolls semidehiscent, globose; septa smooth; seeds brown, midsize (5.5 to 7.0 mg.); flowers funnelform, large (20 to 24 mm. wide); petals uniformly white, flat, midsize (10 mm. wide by 12 mm. long); anthers blue; filaments white; style white; stigma lavender. Plants moderately resistant to wilt but susceptible to rust.

History.—Diadem (C. I. 321) (Ottawa No. 787) was selected in 1910 from a cross La Platta × White Flowering B., by Sir C. E. Saunders, Division of Agronomy, Central Experimental Farm, Ottawa, Canada.

Distribution.—Formerly grown to some extent in Canada.

Comparison.—Blanc (C. I. 323) (Ottawa No. 62) is similar to and probably has the same origin as Diadem. Flowers and seed of Blanc are somewhat smaller and the plants slightly taller.

JANE

Description.—Plant midheight (16 to 30 in.), early, stems midsize; bolls semidehiscent, subglobose; septa smooth; seeds dull brown, small (4.2 to 5.0 mg.); flowers funnelform, small (14 mm. wide); petals white; anthers yellow; filaments white; style white. Plants somewhat resistant to wilt but susceptible to rust. Flowers similar to Ottawa white-flowered but smaller with yellow anthers. The anther walls are cream yellow, the pollen is lemon to orange yellow.

History.—Jane (C. I. 420) was selected by A. C. Arny as an "off-type plant" in a plot of Chippewa (C. I. 178) at University Farm, St. Paul, Minn., in 1924. It was grown as row 84 in the 1925 nursery at University Farm, and has been continued in the classification nursery as a distinct flower type. It is similar to Tammes type 14 (C. I. 778) with white petals and yellow anthers.

Distribution.—Not grown commercially.

PRIMOST

Description.—Plant midheight (20 to 26 in.), early, panicle branches short to midlong, stems small to midsize; bolls semidehiscent, subglobose to globose; septa ciliate; seeds brown, small (3.8 to 4.5 mg.); flowers funnelform, midsize; petals flax blue; anthers blue; filaments and style trace to one-third blue. Plants only slightly resistant to wilt.

History.—Primost (C. I. 12) (Minn. 25) was selected by Willet M. Hays at the Minnesota Agricultural Experiment Station, St. Paul, Minn., in 1894. It was a blue-flowered plant found in a plot of fiber flax, White Blossom Dutch. The

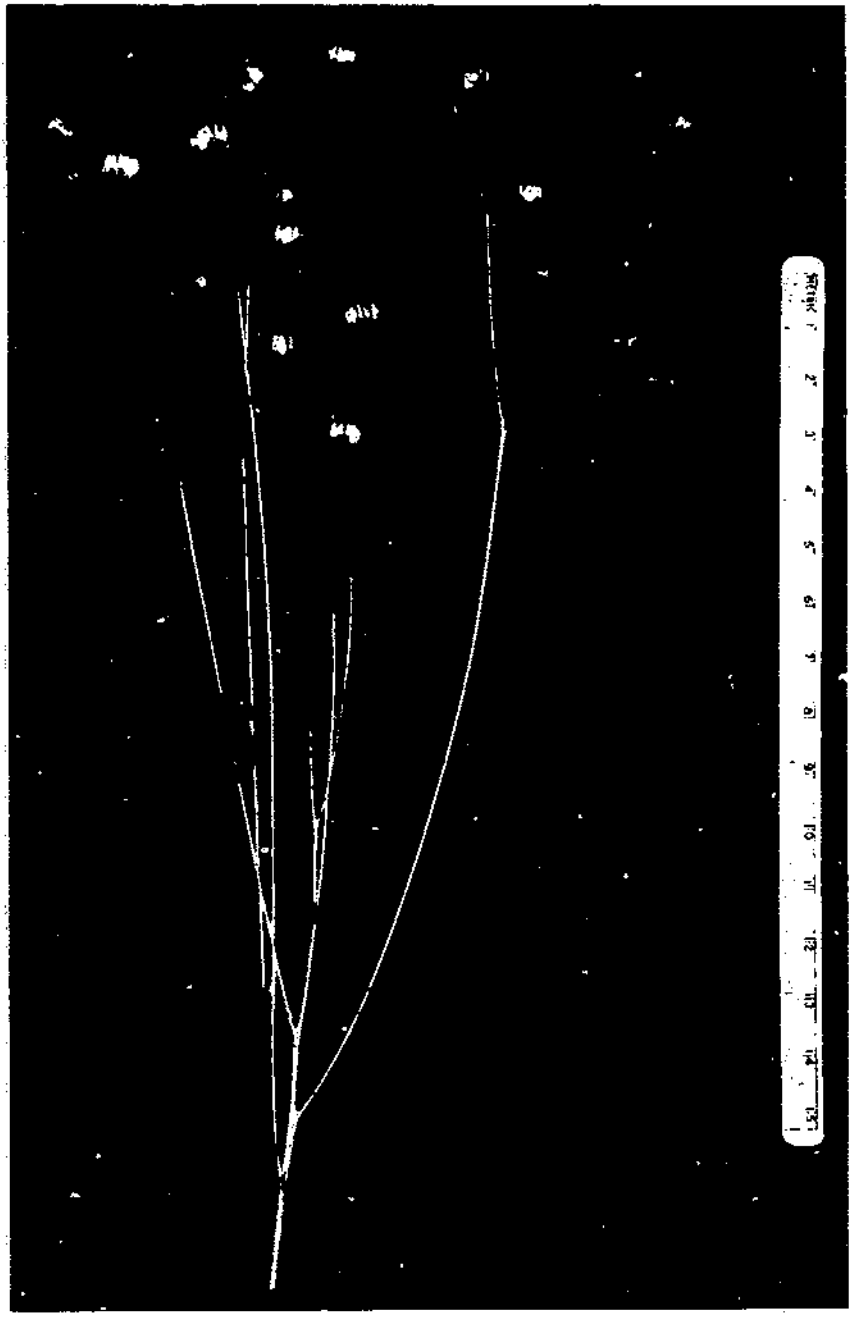

FIGURE 17.—Panicle of Victory.

selection was reselected and tested in "centgener" plots for 5 years, and finally increased and released to farmers in 1902 under the designation Minnesota 25. In 1904 the Minnesota station distributed several hundred bushels to 270 farmers in Minnesota. Later it was named "Primost," a coined name, probably meaning "first in importance." Primost was the first variety of flax to be developed and named in the United States.

Distribution.—Grown extensively in Minnesota and South Dakota from about 1904 to 1930.

N. D. R. 114

Description.—Plant midheight (20 to 28 in.), sparsely branched, not leafy, stems midsize; bolls semidehiscent, subglobose or globose; septa ciliate; seeds brown, small (3.8 to 4.4 mg.); flowers funnelform, midsize; petals flax blue; anthers blue; filaments and style white to one-half blue, not uniform. Plants of short-fiber type, moderately resistant to wilt but susceptible to rust.

History.—N. D. R. (North Dakota Resistant) 114 (C. I. 13) was selected by H. L. Bolley in 1902 from common flax. After continued bulk reselection for wilt resistance at the North Dakota station, it was increased and released to one or more farmers in 1912. N. D. R. 114 was not a high-yielding variety, but it was grown widely because of its superior wilt resistance.

Distribution.—Grown extensively in North Dakota, South Dakota, Minnesota, and Montana from about 1915 to 1936. Thereafter N. D. R. 114 was replaced by Bison, a much superior variety from the standpoint of yield, oil content, and wilt resistance.

LINOTA

Description.—Plant midheight (18 to 26 in.), early, stems midsize, sparsely branched; bolls semidehiscent, subglobose to globose; septa ciliate; seeds brown, small (3.8 to 4.5 mg.); flowers funnelform, midsize; petals flax blue; anthers blue; filaments a trace to one-half light blue; style one-half blue. Linota is moderately resistant to wilt but susceptible to rust.

History.—Linota (C. I. 244) was selected in 1916 by T. E. Stoa at the North Dakota Agricultural Experiment Station in cooperation with the United States Department of Agriculture. It was one of several wilt-resistant plants selected from a plot of Frontier (N. D. No. 155), which was damaged by wilt. The selections were tested for yield and wilt resistance for 7 years before Linota (N. D. 40015) was increased, named, and released to farmers in 1925. The name should not be confused with Lineta (Spanish), a type of small-seeded flax grown in Argentina.

Distribution.—Grown widely in North Dakota from 1926 to 1935 and in Kansas from about 1939 to 1945.

BUDA

Description.—Plant midheight (22 to 26 in.), midseason, stems midsize, stout, branched, leafy, panicle midlong, somewhat spreading and leafy; bolls semidehiscent, subglobose to globose; septa ciliate; seeds brown, small (3.8 to 5.0 mg.), relatively long, narrow, and beaked; flowers funnelform, midsize; petals flax blue; anthers blue; filaments one-third blue; style two-thirds blue. Plants resistant to wilt and somewhat resistant to rust under field conditions.

History.—Buda (C. I. 326) (N. D. R. 119) was developed by H. L. Bolley by continued selection of wilt-resistant plants from a sample of seed (P. I. 10018) purchased by Bolley from a junk dealer in Budapest, Hungary, in 1903. Selections were made each year from 1904 to 1914 at the North Dakota station. Ten pounds of seed was turned over to T. E. Stoa in the spring of 1922 for plot tests. Bolley released 2 bushels of seed to each of eight farmers in North Dakota for planting in 1924, and a second distribution of 2 to 4 bushels was made to six additional growers in 1925. The name is taken from the city of Buda (or Budapest), the source of the original seed.

Distribution.—Grown rather extensively in North Dakota, South Dakota, and Minnesota from 1928 to 1940, and still grown to some extent because of its moderate rust resistance.

REDWING

Description.—Plant midheight (18 to 22 in.), early, stems strong, rarely lodging; bolls semidehiscent, subglobose; septa ciliate; seeds brown, midsize (4.3 to

5.3 mg.); flowers funnelform, midsize; petals light blue; veins violet; anthers blue; filaments white; style about one-fourth light blue. Plants moderately resistant to wilt but susceptible to rust.

History.—Redwing (C. I. 320) was developed through cooperative flax-breeding investigations of the Division of Agronomy and Plant Pathology at the University of Minnesota. The original seed P. I. 10006 (Minn. 91) was introduced from Europe by H. L. Bolley in 1903 and grown at University Farm, St. Paul, Minn., from 1904 to 1913. Bulk selections of wilt-resistant plants were made in 1914 and 1915 and individual plant selections were made in 1916. From one of these lines (Minn. 93–1) H. D. Barker (3) made some 30 plant selections in 1919. The first seed released was not uniform for petal color and reselections were made by A. C. Arny. Finally, in 1928, pure seed was released to farmers through the Minnesota Crop Improvement Association.

Distribution.—Grown chiefly in Minnesota and South Dakota, and because of its early maturity grown to some extent in Alberta and Saskatchewan in Canada.

BIWING

Description.—Plant midheight (20 to 28 in.) (taller than Redwing), midseason, stems midsize, panicle midlong, spreading; bolls semidehiscent, subglobose; septa ciliate; seeds brown, midsize (4.5 to 6.5 mg.); flowers funnelform, midsize (15 to 18 mm. wide); petals light blue; anthers blue; filaments a trace of light blue; style a trace of blue. Plants moderately resistant to wilt but susceptible to rust.

History.—Biwing (C. I. 917) was developed by A. C. Arny from a cross of Bison by Redwing made in 1929 at University Farm, St. Paul, Minn. The object was to combine the high oil content of Bison with the better drying quality (high iodine number) of Redwing. After extensive testing of some 40 selections from this cross, 2 lines—Biwing (C. I. 917) and Redson (C. I. 970)—were increased, named, and released to growers. In 1941 Biwing was released to a few growers, and in 1942 small lots of seed (1 to 10 bushels) were distributed to some 370 growers of certified seed in Minnesota.

Distribution.—Grown extensively in Minnesota and to some extent in Iowa and South Dakota.

SHEYENNE

Description.—Plant midheight (20 to 26 in.), early, stems midsize, panicle branches leafy; bolls semidehiscent, subglobose; septa ciliate; seeds brown, midsize (4.5 to 6.0 mg.); flowers funnelform, midsize; petals flax blue; anthers blue; filaments one-half light blue; style one-half blue. Plants highly resistant to wilt and rust.

History.—Sheyenne (C. I. 1073) was selected by H. H. Flor at the North Dakota Agricultural Experiment Station from a cross of Ottawa 770B × Buda. The first increase of seed (280 pounds) was grown at El Centro, Calif., during the winter of 1942–43. Because of the urgent need for a rust-resistant variety, this foundation seed was increased rapidly in North Dakota. Seven acres were grown in 1943, 80 acres in 1944, 985 acres in 1945, and about 18,000 acres in 1946. The name Sheyenne comes from the river of that name that meanders through eastern North Dakota.

Distribution.—Grown widely in North Dakota and to some extent in South Dakota and Canada.

ARROW

Description.—Plant midheight (24 to 30 in.) (taller than Sheyenne), midseason, stems midsize, stout, panicle midlong, spreading; bolls semidehiscent, subglobose to globose; septa ciliate; seeds brown, midsize (5.5 to 7.0 mg.); flowers funnelform; petals flax blue; anthers blue; filaments white; style a trace of blue. Plants resistant to wilt and rust.

History.—Arrow (C. I. 1070) (reg. 5)[7] was developed in cooperative flax breeding research between the United States Department of Agriculture and the Montana, Minnesota, and North Dakota Agricultural Experiment Stations.

[7] Reg. refers to number registered through a cooperative agreement between the Bureau of Plant Industry, Soils, and Agricultural Engineering, and the American Society of Agronomy.

Three outstanding varieties were selected from a cross of Renew by Bison made by the writer at Bozeman, Mont., in 1938. The F_7 generation was grown at El Centro, Calif., during the winter of 1938–39. Numerous selections for wilt and rust resistance were made in the F_8 generation at St. Paul, Minn., and Fargo, N. Dak., in 1940. These were grown in 5-foot rows at Fargo in 1941. One of these (D41–62) was assigned C. I. No. 1070 and increased rapidly by growing two crops each year at El Centro and at Bozeman. In 1943, 18,000 pounds of certified foundation seed was grown by B. A. Black, Gallatin Gateway, Mont. This seed was distributed to growers of certified seed in Montana in 1944.

Distribution.—Grown widely in Montana and to some extent in North Dakota and Canada.

REDSON

Description.—Plant midheight (20 to 26 in.), early, stems midsize, stout, erect, rarely lodging; bolls semidehiscent, subglobose to globose; septa ciliate; seeds brown, midsize (4.3 to 6.3 mg.); flowers funnelform, midsize; petals deep flax blue; anthers blue; filaments one-half blue; style three-fourths blue. Plants highly resistant to wilt but more or less susceptible to rust.

History.—Redson (C. I. 970) (reg. 2) (*1*) was selected from a cross of Bison by Redwing made by A. C. Arny in 1929 at the Minnesota Agricultural Experiment Station. The early history of selection was the same as that of Biwing. In the regional varietal tests carried on by the State experiment stations in cooperation with the Division of Cereal Crops and Diseases, Redson was high in yield (19.4 bushels) at Madison, Wis., for the 6-year period 1939–44. The seed was increased in 1942 by the Wisconsin Agricultural Experiment Station, and in 1943, 300 acres were grown as certified seed.

Distribution.—Grown chiefly in Wisconsin.

BISON

Description.—Plant midheight (22 to 30 in.) (taller than Redson), midseason, stems midsize, stout, rarely lodging, panicle midlong; bolls semidehiscent, subglobose to globose; septa ciliate; seeds brown, midsize (5.5 to 7.0 mg.); flowers funnelform, midsize; petals deep flax blue; anthers blue; filaments about one-third blue; style one-third blue. Plants exceptionally resistant to wilt but susceptible to rust. The seeds yield a high percentage of oil, but the oil is relatively low in iodine number.

History.—Bison (C. I. 389) was selected by H. L. Bolley at the North Dakota Agricultural Experiment Station from commercial seed obtained from Lueardie and Co., Ghent, Belgium, in 1911. Selections were made of surviving plants on plot 30, wilt-infested soil, from 1911 to 1915. In 1917 the progeny of 1 plant selected in 1915 proved to be exceptionally wilt-resistant. In this row (243), 112 plants emerged. All survived and were harvested. This selection was not grown again until 1922, when 6 rows were planted. These were uniform and exceptionally wilt-resistant. The seed was finally increased, and in 1926, 6 acres grown by M. . Tandsetter produced 80 bushels of seed. In 1929 about 28,000 acres were grown, and by 1935 it was estimated that 1,700,000 acres were grown in the North Central States and Canada. Bison has been used widely in breeding for wilt resistance.

Distribution.—Grown extensively in North Dakota, Montana, South Dakota, Minnesota, Iowa, and Canada from 1930 to 1943. Since 1943 it has been replaced generally by new rust-resistant varieties.

KOTO

Description.—Plant midheight (22 to 30 in.) (taller than Redson), midseason; bolls semidehiscent, subglobose or globose; septa ciliate; seeds brown, midsize (4.8 to 6.2 mg.); flowers funnelform, midsize; petals deep flax blue; anthers blue; filaments white or with trace of blue; style one-half blue. Plants highly resistant to wilt but susceptible to one or more races of rust.

History.—Koto (C. I. 842) (reg. 7) was selected from a cross (Reserve × Morye) × Bison, made by J. C. Brinsmade, Jr., at the Northern Great Plains Field Station, Mandan, N. Dak., in 1930. Selections were grown in triplicate rows on wilt-infested soil in 1935. One of these was assigned C. I. No. 842 and later named Koto. After extensive testing at several stations, Koto was increased by the North Dakota Agricultural Experiment Station, and in 1943 it

was released to growers of certified seed in North Dakota, South Dakota, and Minnesota. In the earlier tests, Koto was definitely resistant to rust but not immune from it; later, it appeared that the rust to which Koto is susceptible increased in prevalence and spread in the territory where Koto is grown.

Distribution.—Grown extensively in North Dakota, Minnesota, and South Dakota.

NOVELTY

Description.—Plant midheight (20 to 25 in.), midseason to late, stems midsize, stout, leafy; bolls semidehiscent, globose; septa ciliate; seeds "cinnamon brown" with tawny tip, midsize (5.0 to 6.5 mg.); flowers funnelform, midsize; petals flax blue; anthers blue; filaments white; style white. Plants susceptible to wilt but somewhat resistant to rust.

History.—Novelty (C. I. 140) was a plant selection from Novo Rossisk, made by C. E. Saunders at the Central Experimental Farm, Ottawa, Canada. The seed was increased and grown at Canadian experimental stations as early as 1915. The original variety, Novo Rossisk (C. I. 27), was obtained by the Ottawa Experiment Station from the Russian Black Sea port of Novorossisk.

Distribution.—Formerly grown to some extent in Canada.

Comparison.—Other varieties of this type include Novo Rossisk (C. I. 27), Billings (C. I. 184), and Crown (C. I. 327, C.A.N. 2109).

ROYAL

Description.—Plant midheight (20 to 26 in.), midseason to late, stems midsize, stout, leafy; bolls semidehiscent, globose; septa ciliate; seeds "cinnamon brown" with tawny tip, midsize (4.5 to 6.0 mg.); flowers broadly funnelform (18 to 20 mm. wide); petals light blue; anthers blue; filaments white; style white or with a trace of pale blue. Plants resistant to most North American races of rust and moderately resistant to wilt. Royal is satisfactory in yield of oil, but the oil is low in iodine number.

History.—Royal (C. I. 828) (C.A.N. 2266) originated as a plant selection from Crown (C. I. 327) (C.A.N. 2109) made at the University of Saskatchewan, Saskatoon, Saskatchewan, Canada, by J. B. Harrington in 1928. It was selected for its wilt resistance. Its origin probably traces back by selections to Nova Rossisk as follows: Nova Rossisk→Novelty→Crown→Royal. In plant and seed characters Royal is similar to Crown and Novelty. It was released to farmers in Saskatchewan in 1938.

Distribution.—Grown extensively in Saskatchewan, Alberta, and Manitoba, Canada, and in the States of North Dakota, Montana, and South Dakota. After the flax rust epidemic of 1942, several thousand bushels of Royal flaxseed were imported and grown in North Dakota, South Dakota, and Montana.

MINERVA

Description.—Plant midheight (22 to 28 in.), midseason to late, stems midsize, panicle branches midlong, spreading to form a broad panicle; bolls semidehiscent or nearly indehiscent, globose; septa ciliate; seeds yellow, midsize (5.5 to 6.0 mg.); flowers funnelform, midsize; petals bluish violet; anthers blue; pollen almost colorless; filaments two-thirds violet blue; style one-third blue; stigma purple. Plants moderately resistant to wilt and rust. The yellow seeds yield a high percentage of oil of high iodine number. Minerva can be identified readily by its unusual combination of yellow seed and bluish-violet petals.

History.—Minerva (C. I. 1081) was developed by A. C. Arny at the Minnesota Agricultural Experiment Station from a cross of Bison by Reba (C. I. 649) backcrossed to Bison four times. The original cross was made in 1932. Numerous selections made from the backcrosses indicate that the high oil content and high iodine number of the oil apparently was linked with the factor for yellow seed. Finally the seed of nine uniform and similar selections was combined in 1942 for testing and increase.

Distribution.—Grown chiefly in northwestern Minnesota.

Fiber Flax Varieties

In yield of seed most fiber varieties are inferior to the better seed-flax varieties. In the classification nurseries grown under irrigation

at Bozeman, Mont., from 1926 to 1940, the seed yield of fiber varieties ranged from 50 to 80 percent of the yield of such varieties as Redwing and Bison. Cirrus (C. I. 727), grown in the uniform regional nurseries at 19 stations in 1941, averaged 9.4 bushels per acre as compared with 15.6 for Redwing and 16.0 bushels for Bison.

SAGINAW

(Type Variety)

Description.—Plant tall (30 to 38 in.), early to midseason, stems midsize, relatively stout, panicle midlong to long, spreading; bolls semidehiscent, subglobose; septa ciliate; seeds brown, small (3.7 to 5.0 mg.); flowers funnelform, midsize (14 to 16 mm. wide); petals small (8 mm. wide by 11 mm. long), flax blue with violet veins; anthers blue; pollen pale to light blue; filaments one-third light blue; style two-thirds blue. Plants moderately resistant to wilt but susceptible to rust.

History.—Saginaw (C. I. 207) (F. I.[1] 1005) was developed by the then Division of Fiber Investigations, Bureau of Plant Industry, United States Department of Agriculture, in cooperation with the Michigan Agricultural Experiment Station. The improvement of fiber flax was begun in 1909 when A. E. Mayland made hundreds of plant selections from fields of blue-blossom Dutch flax in Sanilac County, Mich. The work of testing was continued by L. V. Crandal (1910–12); F. C. Miles (1913–17); and R. L. Davis (1917–20). Finally, selection No. 1005 was chosen on the basis of yield and wilt resistance for increase. It was named "Saginaw," and seed was released to flax growers in Michigan in 1920.

Distribution.—Grown widely in Michigan and to some extent in Oregon and in Canada from about 1920 to 1935. A similar variety, F. I. 3, was grown to a limited extent in Michigan after its release in 1931.

Comparisons.—Two other varieties of similar type (blue-flowered, the bolls with ciliate septa) were developed in the same experiments. Peerless (C. I. 695) was selected from Saginaw and F. I. 3 (C. I. 694) was selected from Riga (commercial seed shipped from the port of Riga in Latvia). Both varieties were selected by R. L. Davis and tested for several years by B. B. Robinson. F. I. 3 was released to growers in 1931. As compared with Saginaw, Peerless and F. I. 3 have somewhat smaller stems, shorter panicles, and slightly smaller seeds. The three varieties, however, can be scarcely distinguished.

J. W. S.

Description.—Plant tall (30 to 40 in.), early to midseason, stems small to midsize, panicle midlong to long; bolls semidehiscent, subglobose; septa smooth; seeds brown, small (3.5 to 4.3 mg.); flowers funnelform, midsize (12 to 15 mm. wide); petals flax blue; anthers blue; filaments about one-half light blue; style two-thirds blue. Plants somewhat resistant to wilt but susceptible to rust.

History.—J. W. S. (C. I. 388) (P. I. 73560) was selected during the period 1911–15 by J. Vargas Eyre, Director of the Linen Industry Research Association, County Antrim, Ireland. The name "J. W. S." was given in honor of John W. Stewart, a prominent flax grower and sponsor of the Linen Research Association. Seed (P. I. 73560) was introduced by the Division of Fiber Crops of the United States Department of Agriculture in 1927.

Distribution.—Grown in States of Michigan and Oregon and in Canada, Ireland, and Scotland. The propagation of seed of J. W. S. for planting in Great Britain and Ireland was carried on extensively in Canada, and in 1931 about 150 tons of seed were available for export.

Comparisons.—The Linen Industry Research Association has developed by selection several so-called varieties that are so similar in plant, flower, and seed characters that they cannot be distinguished with certainty from J. W. S. They differ perhaps in yield and quality of fiber, but they can hardly be distinguished by morphological characters. These include Pioneer (Liral 1) (C. I. 723); Bentall (Liral 2) (C. I. 724); Monarch (Liral 3) (C. I. 725); Crown (Liral 4) (C. I. 726); and Gossamer (C. I. 728). Other similar varieties grown in the classification nurseries include American fiber (Minn. 165) (C. I. 165);

[1] F. I.=Fiber Investigations.

Dalgonetz (C. I. 498); and Russian selections by Althausen (C. I. 628 and 630). Bateson (C. I. 373) differs from J. W. S. in being taller and the seeds somewhat smaller. All have common flax-blue flowers with blue anthers, the filaments and style partly blue, and small brown seeds. The bolls are semidehiscent, subglobose, and the septa smooth.

CIRRUS

Description.—Plant tall (30 to 38 in.), early to midseason, stems small to midsize, panicle midlong; bolls semidehiscent, subglobose; septa smooth; seeds brown, small (3.6 to 4.5 mg.); flowers funnelform, midsize; petals flax blue; anthers blue; filaments one-third light blue; style two-thirds blue. Plants somewhat resistant to wilt but susceptible to rust. Cirrus is similar to J. W. S., but the stems are somewhat finer.

History.—Cirrus (C. I. 727) was developed by the Ministry of Agriculture, Government of northern Ireland, Stormont, Belfast, County Antrim, Ireland. Its origin is not known to the writer. Seed was released in 1932.

Distribution.—Grown in Oregon and in Canada from about 1933 to 1940, generally replacing J. W. S.; and in Peru, South America.

Synonym.—Stormont Cirrus.

PINNACLE

Description.—Plant tall (30 to 38 in.), early to midseason, stems midsize, panicle midlong; bolls semidehiscent, subglobose; septa ciliate; seeds brown, small (3.8 to 5.0 mg.); flowers funnelform, midsize (14 to 16 mm. wide); petals broad, flat, white, without colored veins; anthers blue; filaments white; style white; stigma white or lavender. Plants resistant to wilt but susceptible to rust. Pinnacle has moderately stiff stems and is resistant to lodging, but its fiber is said to be of poor quality.

History.—Pinnacle (C. I. 683) was selected by B. B. Robinson in 1924, in cooperation with the United States Department of Agriculture and the Michigan Agricultural Experiment Station. It was found in a plot of blue-flowered Saginaw, probably as a mixture. The seed was increased, and in 1931 it was released for limited plantings in Michigan.

Distribution.—Formerly grown to a limited extent in Michigan.

Comparisons.—Tammes Common White (C. I. 776) is similar to Pinnacle, the plants being somewhat shorter and the seeds slightly smaller. Other lines grown in the classification nurseries include C. I. 421, Minn. 25 410, and C. I. 448 (Saginaw White). All are similar in having small semidehiscent, subglobose, bolls with ciliate septa.

CONCURRENT

Description.—Plant tall (30 to 38 in.), midseason to late, stems midsize, panicle short to midlong; bolls semidehiscent, subglobose, small; septa smooth; seeds brown, small (3.8 to 5.0 mg.); flowers funnelform, midsize (14 to 16 mm. wide); petals white; anthers blue; filaments white; style white. Plants susceptible to rust and wilt, but under favorable conditions relatively high in seed production.

History.—Concurrent (C. I. 801) was developed by J. C. Dorst, Council for Plant Breeding, Leeuwarden, Netherlands, by selection of a pure line from the white-flowered fiber flax, which had been grown in Friesland Province for a century. According to Tammes (54) one or more white-flowered plants were found by a Friesland farmer about the year 1816 in a field of blue-flowered flax of Russian origin. The white-flowered flax was increased by a Friesland landholder and grown generally in that province for a hundred years or more. Dr. Dorst made numerous pure-line selections in the years 1920–22. Concurrent was one of these. It was released soon after 1926. The writer obtained seed (C. I. 801) from B. C. Algra, a seed dealer of Sliens, Netherlands, in 1935.

Distribution.—Grown in the State of Oregon, the Dominion of Canada, and the Netherlands.

Comparisons.—Dorst F-6 (C. I. 800) and Dorst I-13 (C. I. 799), the seed obtained from B. C. Algra, are similar to Concurrent in boll, flower, and plant characters. Dorst I-13 has slightly smaller seeds than those of Concurrent.

Other samples of white-flowered fiber flax have been grown in the classification nurseries under the name of white-flowering Friesland (C. I. 56) and White Blossom Dutch (C. I. 216). These have not been grown in direct comparison

with Concurrent, but records indicate that they were somewhat shorter and earlier in maturity. They were similar in flower and boll characters—the bolls semidehiscent, subglobose, the septa smooth.

NARROW-PETALED VARIETIES

(*Linum usitatissimum* group *angustipetalum*)

The group *angustipetalum* includes a wide range of varieties, all characterized by white, narrow, involute petals and yellow anthers; the narrow widely separate petals forming a so-called star-shaped flower. The seeds are greenish yellow, pale yellow, or brown, and range from small to large. Tammes (*35*) describes two types differing in color of seeds. Tammes, type 11 (C. I. 775) has greenish-yellow seeds, the color matching "ecru-olive" of Ridgway (*29, pl. 30*), whereas type 12 (C. I. 776) has brown seeds. Album, type 13, is a short, stout plant with large brown seeds. In all varieties in this group the filaments, styles, and stigmas are white and the hypocotyls of the seedlings are white; that is, not colored with anthocyanin.

TAMMES CRIMPED-WHITE

(Type Variety)

Description.—Plant midheight (20 to 28 in.), stems midsize; bolls semidehiscent, subglobose; septa smooth; seeds "ecru-olive" (greenish yellow), small (4.0 to 5.0 mg.); flowers small, star-shaped, the petals being widely separate; petals white without colored veins, narrow (4 mm. wide), the margins involute or crimped; anthers yellow; filaments white; style white. Plants susceptible to wilt and rust.

History.—The origin of Tammes crimped-white (C. I. 775) is not known to the writer. Seed was obtained from Tine Tammes, University of Groningen, Netherlands, who used the variety in her genetic studies of flax.

Distribution.—Not grown commercially.

Comparisons.—Similar varieties, including Ottawa Olive B (C. I. 325) and Ottawa 829 C (C. I. 391), were obtained from L. H. Newman, Central Experimental Farm, Ottawa, Canada.

OTTAWA 770B

Description.—Plant midheight (20 to 25 in.), midseason to late, stems midsize, stout, leafy; bolls semidehiscent or nearly indehiscent, globose; septa smooth; seeds pale yellow, midsize (5.0 to 6.0 mg.); flowers midsize, star-shaped; petals white, narrow (6.0 mm. wide), involute; anthers yellow; filaments white; style white. On cool days the petals of the opening buds often cling together, forming a hooded or pear-shaped flower. Plants immune to North American races of rust and moderately resistant to wilt.

History.—Ottawa 770B (C. I. 355) was developed by Sir C. E. Saunders, Central Experiment Farm, Ottawa, Canada, from a cross of Argentine flax, La Plata A, by Ottawa 829C (C. I. 391). The cross was made in 1910. Ottawa 770B has been used extensively in breeding because of its rust resistance and high oil content.

Distribution.—Grown to a limited extent in Canada and used extensively in breeding for rust resistance and drying quality of oil in the United States and Canada.

TALMUNE

Description.—Plant tall (36 to 48 in.), midseason to late, stems large, stout, relatively free from lodging, panicle branches long; bolls semidehiscent, subglobose; septa smooth; seeds yellow, small (4.0 to 5.2 mg.); flowers small, star-shaped; petals white, narrow, involute; anthers yellow; filaments white; style white. Plants resistant to rust and moderately resistant to wilt. In height of

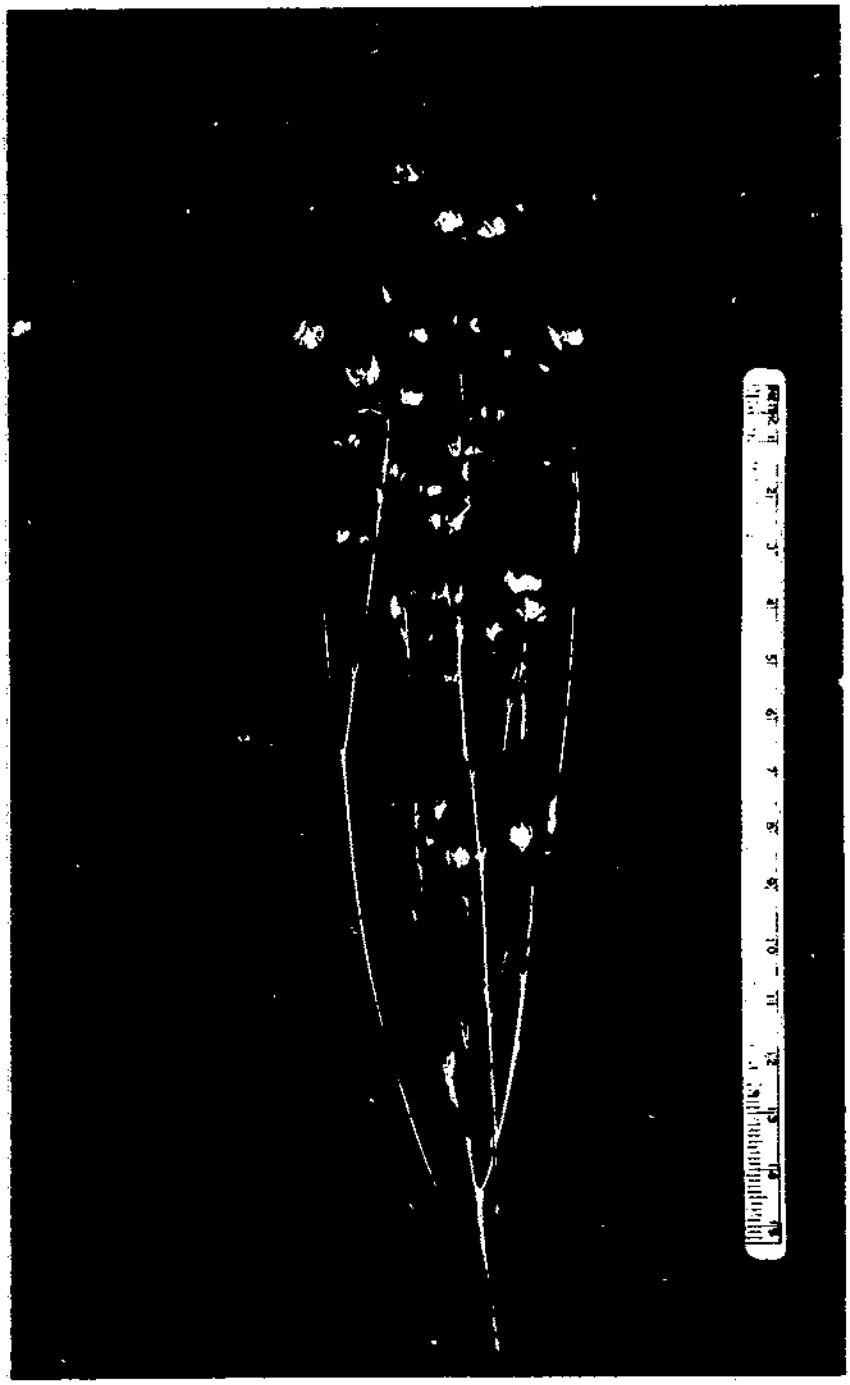

FIGURE 18.—Panicle of Album, type 13.

plant, Talmune may be classed as a fiber type, but it is reported to yield a relatively course fiber that often is too long for economical use in spinning.

History.—Talmune (C. I. 687) is a hybrid variety developed at University Farm, St. Paul, Minn., from a cross between Ottawa 770B and Saginaw, a tall fiber flax. The cross was made by A. W. Henry, and selections were made by Henry and H. A. Rodenhiser in 1924. One of the selections (C. I. 687) was grown by the writer in his classification nurseries for several years, and in 1942 A. C. Arny named it "Talmune."

Distribution.—Not grown commercially.

CRYSTAL

Description.—Plant midheight (24 to 30 in.), midseason to late, stems midsize, panicle branches midlong, erect, forming a rather close panicle; bolls semidehiscent, subglobose to globose; septa ciliate; seeds yellow, midsize (5.5 to 6.8 mg.); flowers star-shaped, midsize; petals white, narrow, involute; anthers yellow; filaments white; style white. Crystal is highly resistant to rust and moderately resistant to wilt and pasmo.

History.—Crystal (C. I. 982) was developed by A. C. Arny, University Farm, St. Paul, Minn., from a cross between Bison and Ottawa 770B. The cross was made by Arny in 1930, and hundreds of selections were made and tested for yield and disease resistance before Crystal was finally selected for increase. Seed was released to farmers in 1944.

Distribution.—Grown in Minnesota and to some extent in South Dakota and North Dakota.

ALBUM, TYPE 13

Description.—Plant short (10 to 15 in.), branched, stems stout, panicle spreading; bolls indehiscent, ovoid, large; septa ciliate; seeds brown, large (7.5 to 9.0 mg.); flowers small funnelform, star-shaped; petals white without veins, narrow (4 mm. wide by 11 mm. long), margins involute; anthers cream yellow, pollen pale yellow; filaments white; style white; stigma white (fig. 18).

History.—Album, type 13, is a distinct variety, quite different from other types segregated by Howard and Khan (*18*).

Distribution.—Not grown commercially but used in genetic studies.

Comparisons.—In a cross of Album × Tammes crimped-white with brown seeds (C. I. 776) the writer found the two varieties to be of the same genetic composition for type of flower (petals and anthers) and for seed color. In another cross, Album × Bison, the writer obtained dwarf plants in F_1, the plants being much shorter than Album, the shorter parent. Segregation occurred in F_2, but the exact ratios were not determined.

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PREFACE

In nearly every irrigated project of the West some lands have become waterlogged or affected in some degree by accumulations of harmful salts. This has impaired such lands for crop production or destroyed them for practical farm use. Drainage problems have gradually become more acute as the agricultural valleys and basins have been developed. Extensive and expensive drainage systems have become necessary to remove excess water and salt from the soil. Many of these systems have not functioned properly because of improper design and installation. Much of the difficulty is due to failure to obtain adequate information on drainage conditions prior to installation, or to lack of information on the technical requirements which must be met for successful drainage.

As part of the research program of the Soil Conservation Service on irrigation, studies on the drainage of irrigated land have been undertaken to develop methods of obtaining and evaluating the information needed for the development of sound engineering practices in the design of drainage systems; methods of drainage; layout, depth and spacing of drains; and types of structures. Research work has been conducted in several of the major irrigated valleys where drainage is necessary if agricultural production is to continue. The material on drainage-investigation methods presented in this bulletin is based largely on studies made over a period of years in Imperial and San Fernando Valleys in California. It is applicable generally to other parts of the West where drainage of irrigated land is a problem.

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